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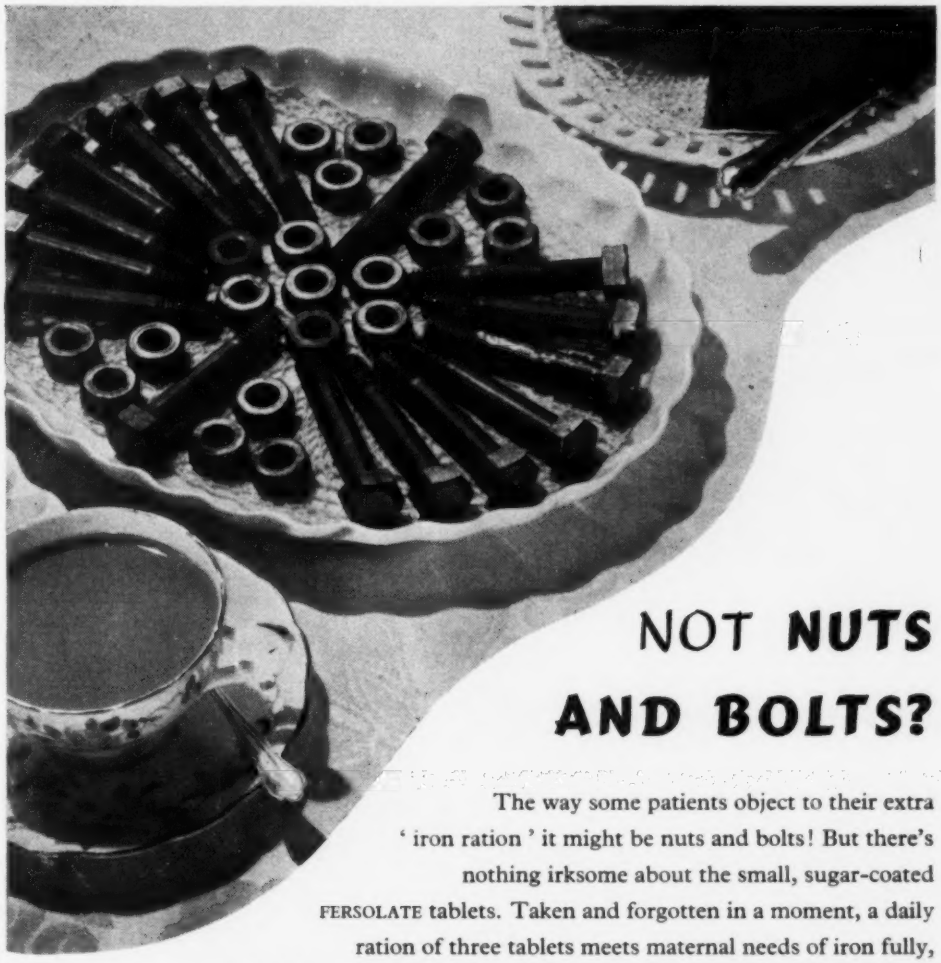

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1. Effect of chelating agent on urinary lead excretion. Comparison of oral and intravenous administration. Proc. Soc. exp. Biol. (1953) 82 : 226.
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ALUMINIUM POWDER INHALATIONS IN THE TREATMENT OF SILICOSIS OF POTTERY WORKERS AND PNEUMOCONIOSIS OF COAL-MINERS

BY

M. C. S. KENNEDY

From the Medical Research Council Treatment Centre, North Staffordshire Royal Infirmary, Stoke-on-Trent

(RECEIVED FOR PUBLICATION DECEMBER 7, 1955)

Haldane in 1918 postulated the theory that the dust of certain mineral rocks had an antidotal effect on the fibrogenic action of siliceous dusts, a theory which has since been put to the test by animal investigators. Kettle in 1932 showed that iron-coated particles of quartz were inert when injected subcutaneously into animals, whereas uncoated quartz caused marked necrosis and cellular change in the subcutaneous tissues. In 1937 Denny, Robson and Irwin found that small quantities of metallic aluminium inhibited the solubility of siliceous material in the beaker, and that quartz particles coated with aluminium failed to produce fibrosis in the lungs of rabbits, whereas particles not so treated caused frank pulmonary fibrosis. Later, in 1939, these three authors working on rabbits showed that the fibrogenic action of quartz could be prevented if 1% aluminium was given independently of the quartz. Gardner, Dworski, and Delahant (1944) were unable to substantiate Kettle's work using iron oxide, but obtained results with aluminium hydroxide similar to those reported by Denny, Robson, and Irwin.

These experimental findings on laboratory animals gave rise to the hypothesis that human silicosis might be prevented, or progression of the established disease arrested, by the prophylactic or therapeutic inhalation of aluminium powder. Subsequently workers in America and Canada published preliminary findings on the value of aluminium inhalations for the treatment of silicosis, and in 1946 Professor E. J. King and Dr. C. L. Sutherland visited Canada and America to review the whole question of aluminium therapy on behalf of the Medical Research Council. In 1947, after their extensive tour, they reported that although many centres claimed symptomatic improvement with this aluminium treatment there was no definite evidence that aluminium retarded the further development of silicosis, or that it caused regression of the established disease. They recommended that carefully planned and controlled investigations be made into the value of this treatment. This recommendation was endorsed by the Aluminium Subcommittee of the Industrial Pulmonary Diseases Committee, and the present report gives an account of the investigation that was carried out in the Stoke-on-Trent area to evaluate the merits of aluminium inhalations for the treatment of established silicosis of pottery workers and pneumoconiosis of coal-miners. The object was to compare the relative efficacy of aluminium inhalations given in two very different doses (one of which was so low as to be effectively an inert control) in relieving symptoms, in improving the patient's functional capacity, and in retarding the progression of established radiological changes.

Type of Patient

It was decided that all patients to be included in the trial must (*a*) have radiological evidence of silicosis or pneumoconiosis associated with a history of exposure to siliceous or coal dusts over a period of at least 10 years ; (*b*) exhibit symptoms caused by the pneumoconiosis ; (*c*) show no evidence of active pulmonary tuberculosis ; (*d*) show no evidence of cardiovascular disease that might produce symptoms which could be confused with those due to pneumoconiosis ; (*e*) be deemed likely to attend regularly for treatment over a number of years and be willing to submit to all the necessary tests of assessment.

Examination of the first hundred patients to present themselves showed the difficulty of making a confident radiological diagnosis of tuberculosis in the pottery workers and also the high incidence of simple hypertension. Consequently a diagnosis of active tuberculosis was made only if tubercle

bacilli were found in the sputum or, when the sputum was negative, there was cumulative evidence of active tuberculosis as judged from the E.S.R., radiological, and clinical findings. Since 34% of the first 100 patients had simple hypertension, *i.e.*, systolic B.P. >160 mm. Hg and diastolic B.P. > 90 mm. Hg, patients with simple hypertension were excluded only if they also showed evidence of cardiac enlargement, orthopnoea, and/or clinical evidence of left ventricular failure.

Assessment of Patient

A detailed initial assessment of each patient was made to cover the industrial history, clinical history, full clinical examination, radiological examination of the chest, a physiological assessment of dyspnoea, and certain laboratory tests. If after the initial assessment the patient was considered suitable for the trial, the quantitative tests were repeated twice at monthly intervals before starting treatment. These repeat pre-treatment assessments were considered necessary to overcome the learning factor in some of the tests and to ensure that the pre-treatment assessment gave a valid picture of the patient's condition. Patients were assessed again after one, two, three, and four years of treatment.

In the assessment of patients before and during treatment particular attention was paid to the following criteria, which were used to determine whether improvement or deterioration occurred.

Clinical Dyspnoeic Grade.—Clinical grading of dyspnoea is notoriously difficult. What a patient is able or unable to do will depend largely on the willingness and practice applied to a particular task. The clinical grading employed was as follows :—

(0) *Capable of Heavy Work.*

(1) *Capable of Moderate Work.*—This is defined as dyspnoea confined to heavy exertion ; can walk quickly ; can climb low gradients without stopping, can dig, and perform any household duty.

(2) *Capable of Light Work.*—This is defined as dyspnoea on walking quickly ; can walk up to one mile on the level ; can climb a dozen stairs without undue distress ; can perform all household duties except carrying loads upstairs ; can do a little digging in the garden.

(3) *Capable of Sedentary Work.*—This means dyspnoea on walking at moderate speed on the flat ; can walk up to 500 yards on the level without stopping, and do sedentary work ; can assist in light household duties, but unable to do heavier work such as scrubbing floors.

(4) *Capable of No Work.*—This is dyspnoea on the slightest exertion ; patient can just potter around the house.

(5) *Total Invalid.*—This means dyspnoea at rest.

Symptoms Referable to Pneumoconiosis or Silicosis.—Every year patients were asked whether there was any change in their general condition ; cough ; sputum ; dyspnoea ; chest pain, energy, and sleep. Each patient was classified (independently by two observers) as the same, better, or worse in respect of each symptom.

Bronchospasm.—Bronchospasm was assessed by auscultation before and after half a minute of exercise. Patients were classed as having bronchospasm if rhonchi were present or accentuated after exercise whether or not they were present at rest. Bronchospasm was not recorded if no rhonchi were audible after exercise, even if they had been present at rest. Later in the investigation an objective test (Kennedy, 1953) was also employed to assess change in bronchospasm, before and immediately after treatment.

Radiological Appearance of Lung Fields.—The films were classified according to the international classification (Cochrane, Davies, and Fletcher, 1951). Some of the potters' films showed a marked increase in linear striations making classification difficult. Postero-anterior, 12 in. × 15 in., chest films were taken of all patients before starting treatment and again at yearly intervals, and the later films were then compared with the pre-treatment films by two observers to assess whether there had been any change.

The Erythrocyte Sedimentation Rate.—Gardner and others (1944) demonstrated that the administration of high concentrations of amorphous hydrated alumina to guinea-pigs influenced unfavourably resistance to tuberculosis. The erythrocyte sedimentation rate was therefore estimated three times before starting treatment and at regular intervals throughout treatment to give early warning of the appearance of active tuberculosis. The E.S.R. was estimated by both the Westergren and Wintrobe methods.

Examination of Sputum for Tubercle Bacilli.—Morning specimens of sputum of all new patients were examined by the Staffordshire Public Health Laboratories for the presence of tubercle bacilli by microscopic, cultural, and guinea-pig inoculation methods. Further specimens were examined in this way at weekly intervals (if necessary for several months) if active tuberculosis was suspected.

Physiological Assessment of Ventilatory Function.—To obtain an objective index of ventilatory function,

three tests were employed: The vital capacity (V.C.), the maximum voluntary ventilation (M.V.V.), and a simple exercise tolerance test (E.T.T.). All patients did these tests on three separate occasions before treatment and thereafter at roughly six-monthly intervals.

The vital capacity and the maximum voluntary ventilation were measured using the procedure described by Gilson and Hugh-Jones (1949). In the exercise tolerance test the exercise ventilation (E.V.) was measured during the last minute of a standard five-minute exercise test as described by Hugh-Jones (1952). The work level was 300 kg. metres per minute; however, even at this low level no E.V. values could be obtained for many patients as they were unable to complete the five minutes' exercise. Consequently patients have been graded according to their performance during the E.T.T. as shown in Table 1.

TABLE 1

NUMERICAL GRADING OF EXERCISE TOLERANCE TEST

Grade	—	Exercise Ventilation (l./min.)
I, II, III, IV	Patient completes five minutes Standard exercise	25 or less; 26–30; 31–40; 41 or more
V	Patient completes more than three minutes' exercise but less than five minutes'	
VI	Patient completes more than one minute's exercise but less than three minutes'	
VII	Patient unable to complete one minute of exercise	

Allocation to Treatment

Of 300 patients who volunteered for treatment 120 satisfied the selection criteria. These were paired on the basis of sex, occupation (potters and coalworkers), and presence or absence of bronchospasm, and as far as practicable for radiological category, dyspnoeic index, and age. A toss of a coin decided the placing of patients in each pair into treatment group A or B. In this way 60 patients were allotted to each treatment group, and these two groups are broadly compared in Table 2.

Treatment Régime

The apparatus for administration of the dust by inhalation is described in Appendix I. Each group of 60 patients was given aluminium inhalations three times a week. For group A, 50 mg. of pure metallic aluminium dust* (provided by the McIntyre Research Foundation) was delivered to the mouth at each treatment. For group B, the dust was carbon black with 1 p.p.m. pure metallic aluminium powder added, and 5 mg. of this dust was delivered to the mouth. All treatments lasted 15 minutes. Three identical cabinets were made, one for group A patients, one for the group B, and a third for delivering compressed air only. All patients were first given inhalations from this third cabinet for at least six weeks (see below): if and when they were deemed suitable for the trial they went to the A or B cabinet according to the group to which they had been previously allotted.

Treatment was started in April, 1949, and continued until the end of November, 1952. Sixty-seven of the 120 patients started treatment in April, 1949, and the remaining 53 joined the trial in small batches at roughly three-monthly intervals over the next two years. Thus, the number of treatments received by a patient depended on when he started treatment and whether or not he continued to attend.

* More than 90% of this dust was within the respirable size range as measured by means of a selective sampler of the type described by Walton (1954).

TABLE 2

TREATMENT GROUPS A AND B COMPARED BEFORE TREATMENT

Index	Group A	Group B
Number of patients (male and female)	60	60
Number of female patients	8	7
Mean age (in yr.)	57·1 (35–73)*	56·0 (39–70)
Mean weight (lb.)	144·0 (108–228)	137·6 (98–209)
Mean clinical grade of dyspnoea	2·8 (0–4)	3·0 (1–4)
Mean E.T.T. grade†	3·3 (1–7)	3·2 (1–7)
Mean vital capacity (l.)	2·73 (1·50–4·25)	2·68 (1·41–4·06)
Mean M.V.V. (l./min.)	59·1 (22–111)	52·8 (17–98)
Mean E.S.R. (mm./hr. Westergren)	12·9 (2–33)	11·2 (2–27)
Number of patients with clinical bronchospasm	15	15
Coalworkers	20	24
Pottery workers	40	36
Simple pneumoconiosis	16	23
Complicated pneumoconiosis	44	37

* Figures in brackets indicate the range of values. † Only 53 group A patients and 55 group B patients attempted the E.T.T.

Results

Lapses.—In a long-term investigation of this type involving elderly and ill patients, it is not surprising that there was a high lapse rate, and Table 3 shows the number of patients falling out at different stages.

At the end of five years, 48 group A and 50 group B patients had been lost during the course of the trial for the different reasons listed. Those falling out because they were "too ill" to attend include the 18 group A and the 17 group B patients who died (analysed later). Most of the patients listed as being "too well" had returned to work and had found further attendance difficult or im-

TABLE 3
NUMBER OF PATIENTS TO FALL OUT AT DIFFERENT STAGES OF THE INVESTIGATION

No. of Treatments Completed	No. of Patients		Stage at which Patients Fell Out	Total No. to Fall Out		Reasons for Fall-out						"Late Starters" Stopping Treatment at End of Trial	
						Too Ill		Too Well		Domestic			
	A	B		A	B	A	B	A	B	A	B	A	B
Less than 100	60*	60*	1st year	17	17	15	11	2	3	0	3	0	0
More than 100	43	43	2nd year	8	12	5	5	1	6	2	1	0	0
More than 200	35	31	3rd year	11	16	2	6	1	2	2	3	6	5
More than 300	24	15	4th year	11	5	3	2	2	1	2	1	4	1
More than 400	13	10	5th year	1	0	1	0	—	—	—	—	—	—
Totals	..	..	. ..	48	50	26	24	6	12	6	8	10	6

* These figures refer to patients in treatment groups A and B.

practicable, and those listed as falling out of the trial for "domestic" reasons were in the main patients with increased home responsibilities. The lapse rate, presented in Table 3, is influenced by the number of "late starters" and of these there were 10 group A and six group B patients attending for treatment when the investigation was concluded.

Presentation of Results.—In Table 3 showing the fate of the 60 patients in each group, it can be seen that 43 patients in each group had at least 101–200 treatments. Thirty-five group A patients and 31 group B patients completed 201–300 treatments, of which 24 and 15 respectively completed 301–400 treatments, and by the end of the trial there were only 13 group A patients and 10 group B patients who completed more than 400 treatments. In presenting the results it will be considered how patients fared after they had received 101–200 treatments, 201–300 treatments, 301–400 treatments, and over 400 treatments, and the findings in the two groups will be compared.

Assessment of Subjective Symptoms after Breathing Air for Six Weeks.—To accustom the patients to the procedure and to obtain an index of the psychological effects, patients received inhalations of pure air for six weeks though they were under the impression that they were receiving aluminium therapy. The first 63 patients were questioned as to whether they had noticed any change in their symptoms. Thirty-six (57%) stated that they felt definitely better in one way or another, whilst the remaining 27 noticed no improvement.

Number of Treatments.—Table 4 gives the average number of treatments received by patients in each group at the time their progress was reassessed.

Group A attended slightly more frequently and for longer periods than group B; the overall average number of treatments per patient in group A was 324 compared with 274 in group B. The difference may have been caused by rather more pressure being put on Group A to attend regularly in the later stages of the trial.

TABLE 4
NUMBER OF TREATMENTS RECEIVED BY GROUPS A AND B PATIENTS

No. of Treatments Received	<100	101–200	201–300	301–400	>400	Overall Average*
Group A						
No of patients ..	60	43	35	24	13	—
Average number of treatments per patient at time of assessment	—	162	246	354	473	324
Group B						
No. of patients ..	60	43	31	15	10	—
Average number of treatments per patient at time of assessment	—	135	239	339	455	274

* The overall average gives the average number of treatments received by all patients to have more than 100 treatments.

Assessment of Patients after 101–200, 201–300, 301–400, and after 400 Treatments.—It has already been shown that the two groups A and B were reasonably comparable at the start of treatment as regards most of the variables (see Table 2).

The mean values of the various indices for the two groups measured after 101–200 treatments, 201–300, 301–400, and more than 400 treatments are given in full in Table 5, from which it is clear that there are no important differences in the behaviour of the two groups.

The patients who had more than 400 treatments were under observation for four years and there were 13 such patients in group A and 10 in group B. The changes of various indices measured for these patients after every 100 treatments are given in Table 6, which again shows no important differences between the groups.

The changes in the individual indices of group A and group B listed in Tables 5 and 6 have been plotted graphically to facilitate comparison of the

TABLE 5

THE MEAN VALUE OF INDICES AT INTERVALS DURING TREATMENT

Index	Values before Treatment		After 100+ Treatments		After 200+ Treatments		After 300+ Treatments		After 400+ Treatments	
	A	B	A	B	A	B	A	B	A	B
Number of patients..	60	60	43	43	35	31	24	15	13	10
Age in years † ..	57·1	56·0	56·7	56·2	56·5	56·9	57·3	59·1	56·7	59·3
Weight in lb. :										
Before	144·0	137·6	144·5	140·6	*146·5	140·1	143·0	141·4	137·5	137·5
After			*147·7*	*141·8*	*148·7*	*140·2*	*146·6*	*139·6*	*138·9*	*137·5*
Change			+3·2	+1·2	+2·2	+0·1	+3·6	−1·8	+1·4	None
Clinical grade of dyspnoea :										
Before	2·8	3·0	2·7	2·9	2·7	2·8	2·6	2·8	2·5	2·9
After			*2·8*	*3·1*	*2·6*	*2·75*	*3·1*	*3·2*	*2·5*	*2·9*
Change			+0·1	+0·2	−0·1	−0·05	+0·5	+0·4	None	None
E.T.T. grade :										
Before	3·3 (53)	3·2 (55)	2·9 (39)	2·9 (40)	3·0 (32)	2·8 (30)	2·6 (21)	2·3	2·6 (12)	2·2
After			*3·2* (39)	*3·1* (40)	*2·9* (32)	*3·1* (30)	*2·1* (21)	*2·3*	*3·1* (12)	*2·5*
Change			+0·3	+0·2	−0·1	+0·3	−0·5	None	+0·5	+0·3
V.C. (l.) :										
Before	2·73	2·68	2·77	2·69	2·77	2·75	2·75	2·98	2·72	3·11
After			*2·69*	*2·54*	*2·54*	*2·54*	*2·39*	*2·61*	*2·36*	*2·62*
Change			−0·08	−0·15	−0·23	−0·21	−0·36	−0·37	−0·36	−0·49
M.V.V. (l. min.) :										
Before	59·1	52·8	62·3	54·0	64·0	57·0	62·6	65·0	59·7	67·9
After			*59·0*	*55·1*	*61·7*	*57·2*	*58·3*	*66·1*	*54·0*	*64·4*
Change			−3·3	+1·1	−2·3	+0·2	−4·3	+1·1	−5·7	−3·5
E.S.R. (mm./hr.) :										
Before	12·9	11·2	13·0	10·3	12·8	10·2 (30)	12·1	10·9	10·8	11·4
After			*11·2*	*8·5*	*11·8*	*10·8* (30)	*10·9*	*12·5*	*11·5*	*9·5*
Change .. .			−1·8	−1·8	−1·0	+0·6	−1·2	+1·6	+0·7	−1·9

* The difference in the means between "after" and "before" arises from the altered number in the group. † The figures in this column give the mean age before treatment.

TABLE 6

CHANGE OF INDICES IN RELATION TO TREATMENT IN RESPECT OF 13 GROUP A PATIENTS AND 10 GROUP B PATIENTS

Index		—			
No. of treatments ..		101–200	201–300	301–400	>400
Weight in lb.	A	+4·8	+1·1	+2·7	+1·4
	B	+2·8	+2·3	+2·0	Nil
Clinical grade of dyspnoea	A	Nil	+0·1	+0·7	Nil
	B	−0·3	−0·2	+0·5	Nil
E.T.T. grade	A	+0·2	−0·1	−0·3	+0·5
	B	+0·4	+0·5	+0·1	+0·3
V.C. (l.)	A	−0·07	−0·13	−0·41	−0·36
	B	−0·25	−0·23	−0·45	−0·49
M.V.V. (l. min.) ..	A	−3·9	−0·3	−1·6	−5·7
	B	−3·8	+2·4	−1·5	−3·4
E.S.R. (mm. hr.) ..	A	−3·4	−2·8	−0·8	+0·7
	B	−2·7	−3·6	−0·3	−1·9

two groups, and the changes in the individual indices are discussed below.

Change in Weight.—From Fig. 1, showing the change in weight, it can be seen that group A showed a small average gain of 3 lb. after 100 treatments, and that they maintained a similar gain with further treatment. Group B on the average gained just over 1 lb. after 100 treatments but with further treatment dropped back to or below their original average. If the changes in weight during treatment of the 13 group A patients and the 10 group B patients receiving more than 400 treatments be similarly plotted as in Fig. 2, it will be seen that there is nothing to choose between the two groups.

Change in Clinical Grade of Dyspnoea.—Figs. 3 and 4 show that the change in clinical grades of dyspnoea was very similar in both groups. The peak in Figs. 3 and 4 after 301 to 400 treatments is possibly an observer inconsistency since at this stage patients were graded by the author alone who had some knowledge of which patients were in each group. On the other occasions grading was made by two observers, one of whom was without any knowledge of the patient's treatment. This inconsistency emphasizes the importance of having two or more observers and a control group for comparison in a long-term trial of this nature.

Change in Exercise Tolerance Grade.—Fig. 5 shows the grading of patients according to their performance on the exercise tolerance test. There was little to choose between the two groups. Fig. 6 shows that the 12 group A patients (only 12 of the 13 patients were able to do this test) fared rather better than the 10 group B patients up to 300 treatments though the difference was not significant ($p > 0.50$).

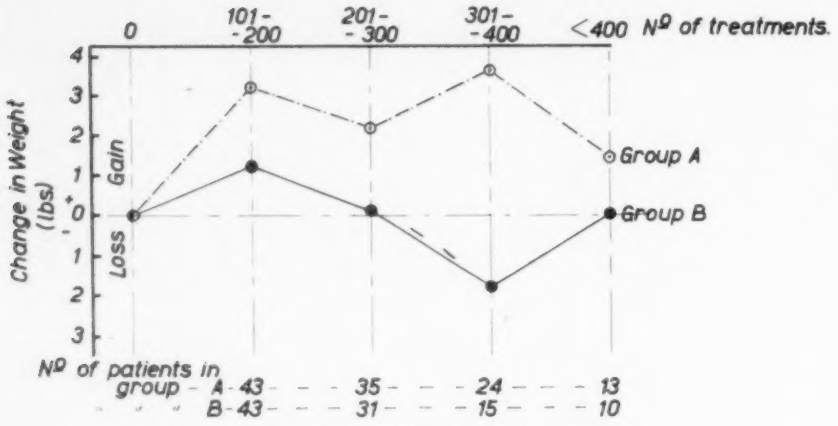

FIG. 1.—Change in weight in relation to treatment.

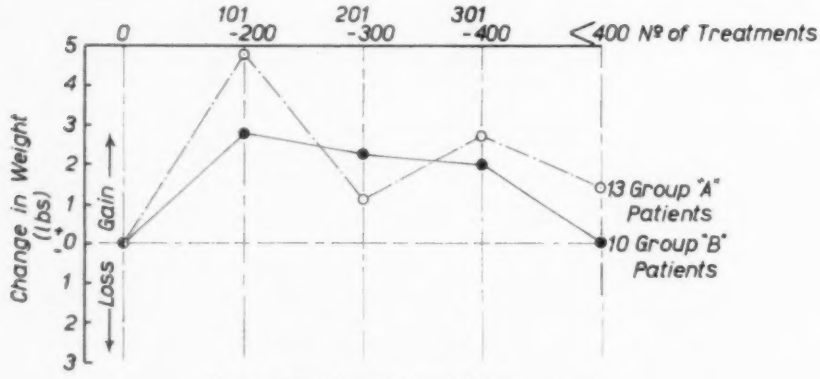

FIG. 2.—Change in weight in relation to treatment.

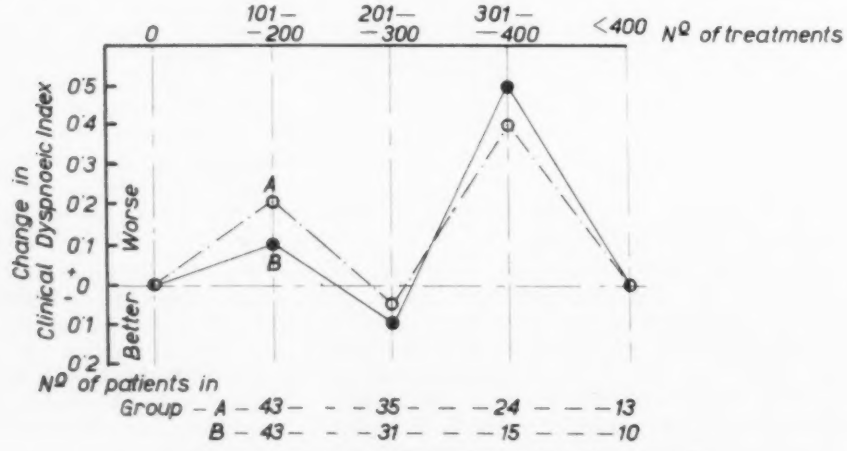

FIG. 3.—Change in clinical grade of dyspnoea in relation to treatment.

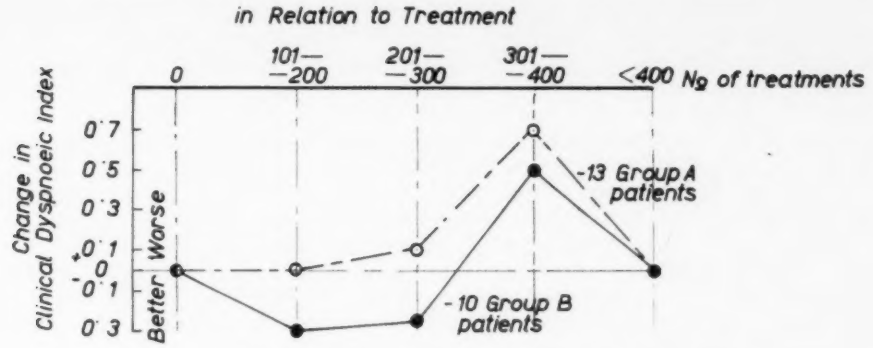

FIG. 4.—Change in clinical grade of dyspnoea in relation to treatment.

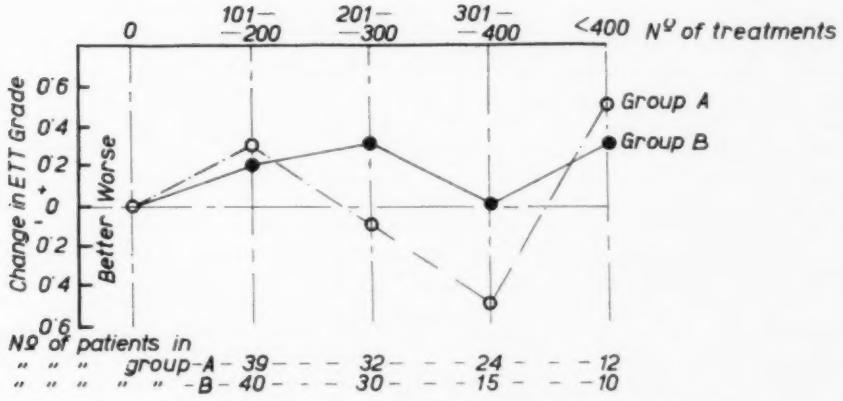

FIG. 5.—Change in exercise tolerance test grading in relation to treatment.

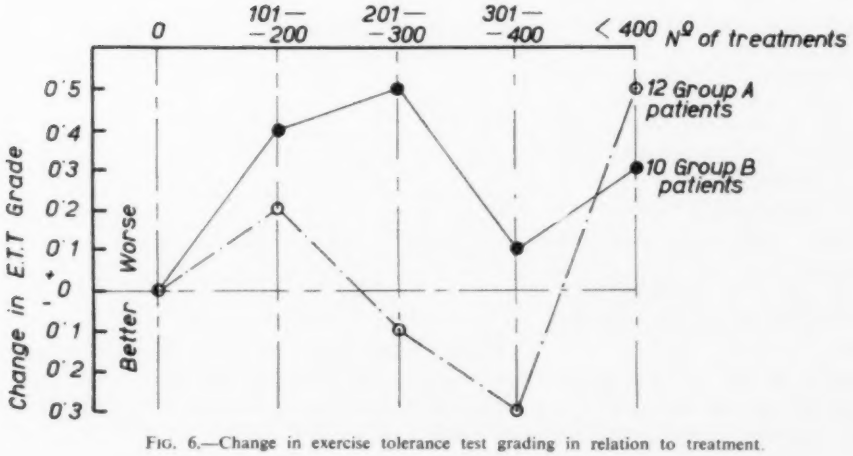

FIG. 6.—Change in exercise tolerance test grading in relation to treatment.

Change in Vital Capacity.—Three pre-treatment assessments of the V.C. were made at monthly intervals, and analysis of these readings showed that the second reading was 5% higher and the third 7% higher than the first reading, which suggests there was a real learning factor to overcome in employing the V.C. on an out-patient basis. The pre-treatment figures recorded in Tables 2, 5, and 6 are those for the third pre-treatment assessment.

Figure 7 shows that the average vital capacity of each group dropped after each hundred treatments by almost exactly the same amount, namely, 100 ml. Expressed in another way each group shows an average drop of roughly 100 ml. for each year of life. Fig. 8 shows a similar trend in the vital capacity of the 13 group A patients and the 10 group B patients.

Change in Maximum Voluntary Ventilation.—Three pre-treatment measurements of the M.V.V., made at monthly intervals, showed that the second reading was 6% higher and the third 15% higher than the first reading. Thus there was again a learning effect.

In Fig. 9 it can be seen that group B patients maintain their original M.V.V. values for the first 300 treatments, whereas the group A patients show a small but progressive fall of the order of 1 litre per minute for each 100 treatments. However, by the end of the trial group B patients showed a similar fall. The initial difference in change of M.V.V. is significant ($t = 2{\cdot}283$ for 84 d.f., $0{\cdot}02 < P < 0{\cdot}05$). During the next hundred treatments the two groups did not change significantly ($t = 1{\cdot}075$ for 64 d.f., $0{\cdot}30 > P > 0{\cdot}20$) and in fact changes were almost inversely related to the initial change. When allowance is made for this the mean changes are almost identical ($t = 0{\cdot}050$ for 63 d.f., $P > 0{\cdot}90$). It appears that subsequent changes add little to the initial findings. The initial drop might be caused by treatment A producing a slightly greater broncho-constrictor effect than treatment B. However, if the 13 group A patients and the 10 group B patients be compared (Fig. 10) it can be seen that except for the one instance in the 200 treatment level, both treatment groups show a similar change.

Change in Erythrocyte Sedimentation Rate.—The erythrocyte sedimentation rate was measured throughout the investigation in an effort to obtain some index of the infectivity of both groups. Figs. 11 and 12 show that there was little difference between the two groups.

Change in Bronchospasm.—It has been suggested that aluminium inhalations might be helpful in the relief of bronchospasm (Hannon, 1944). In this investigation 15 patients in each treatment group had clinical evidence of bronchospasm at the start of treatment. At the end of a year's treatment only eight of the patients in group A and nine of the patients in group B, who had originally been classed as having bronchospasm, were left in the trial. On re-examination at this time all these patients still had clinical evidence of bronchospasm, and it was found that two further patients in each group had developed bronchospasm. Of the 13 group A patients to complete more than 400 treatments, only one had bronchospasm before treatment, which was still present at the end of treatment, when a further two patients had developed signs of bronchospasm. Of the 10 group B patients to complete more than 400 treatments, only one had bronchospasm at the start of treatment, which was still present at the end of treatment, when no other patient in this group had this complication. These findings suggest that neither treatment A nor B relieved bronchospasm.

Change in Radiological Picture.—The 60 patients in each group were radiographed before the start of treatment and yearly afterwards (or more frequently if changes appeared to be taking place). The follow-up plates taken after the cessation of treatment were compared with the pre-treatment plates. The films of each patient were presented to two observers reading together in a random manner so that they were unaware which was the first or the last films of any particular patient and also to which group they belonged. They reported definite radiological changes in pneumoconiosis in 15 and doubtful changes in 10 sets of films, and changes other than pneumoconiosis in two further patients. The analysis of the joint readings by these two observers is given in Table 7.

TABLE 7
SUMMARY OF RADIOLOGICAL CHANGES

Treatment Group	A	B
No. of patients at start of treatment	60	60
No. of patients with no follow-up films	4	4
No. of patients with definite progression	7 } 9*	6 } 8†
with doubtful progression	2 }	2 }
No. of patients with definite regression	2 } 4‡	0 } 4§
with doubtful regression	2 }	4 }
No. of patients showing lung changes other than pneumoconiosis	0	2
No. of patients showing no radiological change	43	42

* One coalworker and eight pottery workers.
† Six coalworkers and two pottery workers.
‡ All pottery workers.
§ One coalworker and three pottery workers.

The changes were classified into no change, definite and doubtful "progression", or "regression". The progression observed in the nine group A and eight group B patients consisted either in an ex-

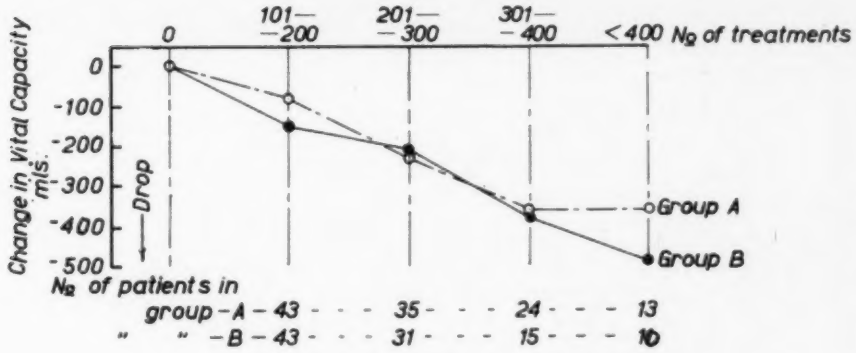

FIG. 7.—Change in vital capacity in relation to treatment.

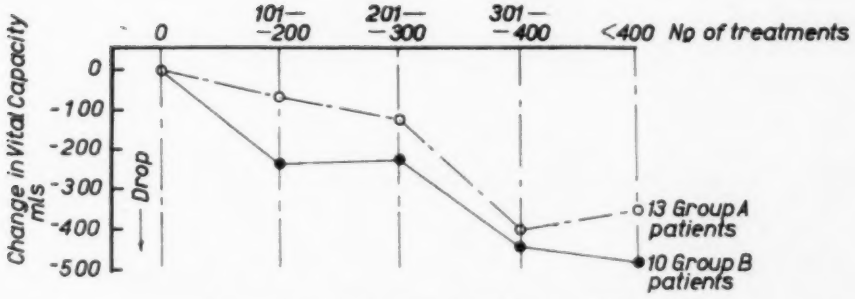

FIG. 8.—Change in vital capacity in relation to treatment.

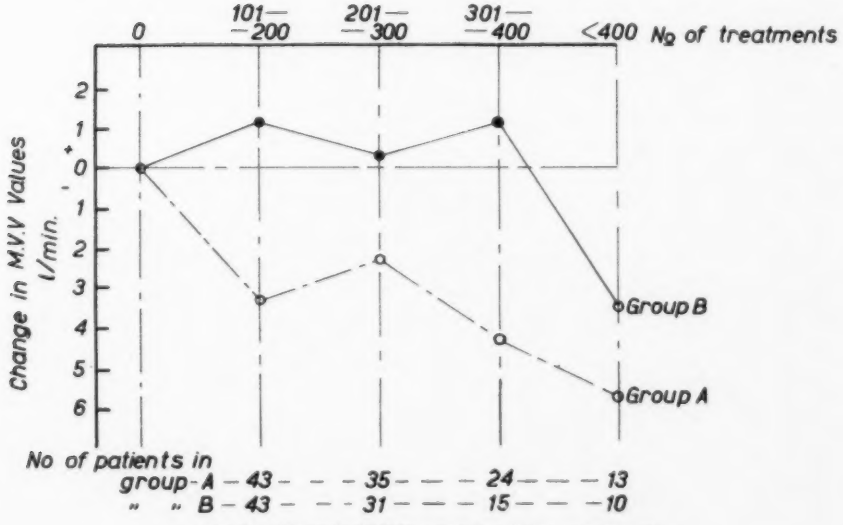

FIG. 9.—Change in M.V.V. values in relation to treatment.

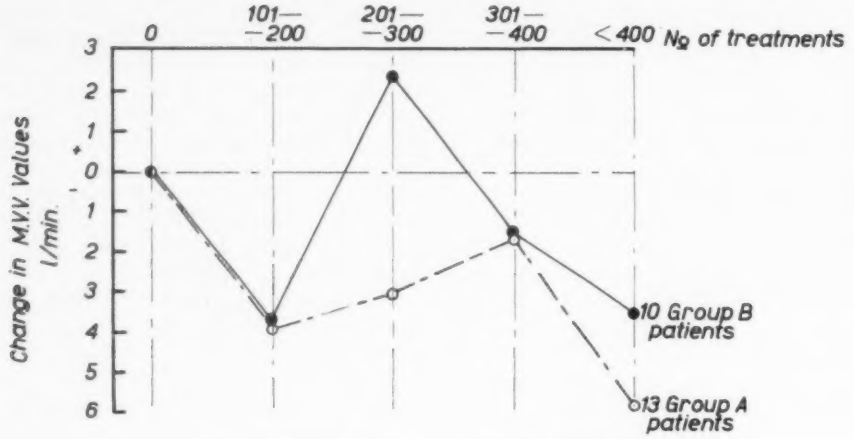

FIG. 10.—Change in M.V.V. values in relation to treatment.

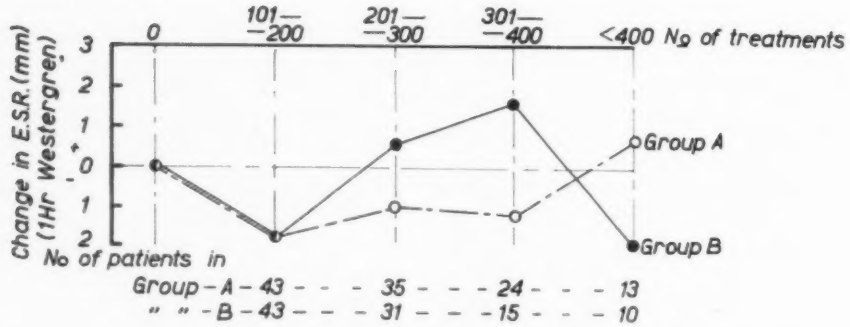

FIG. 11.—Change in erythrocyte sedimentation rate in relation to treatment.

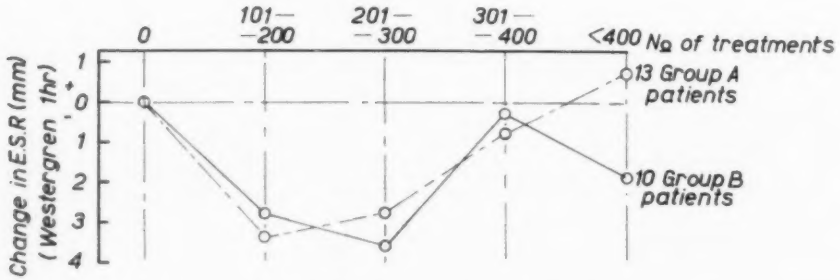

FIG. 12.—Change in erythrocyte sedimentation rate in relation to treatment.

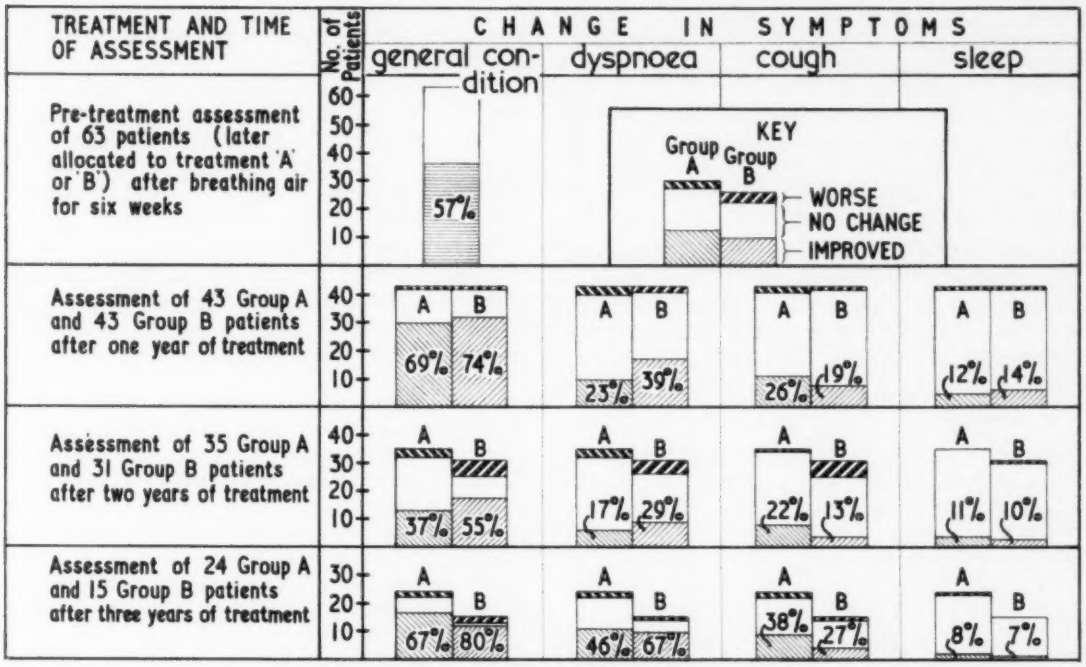
TREATMENT AND TIME OF ASSESSMENT
No. of Patients
CHANGE IN SYMPTOMS
general condition
dyspnoea
cough
sleep
KEY
Group A
Group B
WORSE
NO CHANGE
IMPROVED
Pre-treatment assessment of 63 patients (later allocated to treatment 'A' or 'B') after breathing air for six weeks
57%
Assessment of 43 Group A and 43 Group B patients after one year of treatment
69% 74% 23% 39% 26% 19% 12% 14%
Assessment of 35 Group A and 31 Group B patients after two years of treatment
37% 55% 17% 29% 22% 13% 11% 10%
Assessment of 24 Group A and 15 Group B patients after three years of treatment
67% 80% 46% 67% 38% 27% 8% 7%

FIG. 13.—Change in patients' symptoms at intervals during treatment.

tension of existing massive fibrosis or the development of new shadows. In those showing radiological progression there was, with the exception of one patient, no change in simple pneumoconiosis.

Four group A and four group B patients were classified as showing doubtful or definite radiological regression : in all these patients the changes were compatible with the natural history of the disease and consisted in a diminution in the size of massive shadows probably due to scarring.

Of the 44 coalworkers included in the trial, seven were classified as showing progression and one as showing regression after one or more years : the radiological changes that were observed were similar to those described by Davies and Mann (1948) in their follow-up radiological study of coalworkers' pneumoconiosis, and by Fletcher (1945) in his detailed description of the natural history of the disease. In the coalworkers showing radiological progression there was no associated increase in the erythrocyte sedimentation rate and none of them developed open tuberculosis. There were no deaths.

Ten of the 76 pottery workers showed evidence of progression after one or more years. Five of these 10 patients died. The causes of death were bronchial carcinoma (1), congestive heart failure (1), silicosis (1), silicosis and tuberculosis (1), and causes unknown (1). In the 10 pottery workers with radiological progression the E.S.R. increased during treatment to over 20 mm./hr. in two patients due to infection which was probably tuberculous. Seven pottery workers were classified as showing radiological regression. Three of these died and the causes of death were congestive heart failure with emphysema and silicosis (1), silico-tuberculosis (1), and causes unknown (1).

Symptomatic Change.—The change in symptoms was assessed by the author and Dr. James Knott independently. Before receiving either treatment but after breathing air alone from the cabinets for six weeks, 63 patients were questioned about their symptoms in an effort to obtain a measure of the probable psychological response : Fig. 13 shows that 57%, *i.e.*, 36 of the 63 patients, claimed improvement in their general condition.

After one, two, and three years of treatment, group A and group B patients were asked whether they were improved, the same, or worse as regards their general condition, dyspnoea, cough, and sleeping. The results are given graphically* in Fig. 13, which shows that there is little to choose between the two groups as regards change of symptoms.

The only symptom that can be checked against

*Tables available on request.

objective measures is dyspnoea, and in Appendix III the change in this symptom, experienced by the 24 group A and 15 group B patients to receive three years of treatment, is given together with the change in the vital capacity and the maximum voluntary ventilation. It will be seen from this Appendix that there is no general relationship between the subjective findings and the objective measures employed.

Deaths during and after Treatment.—Five years after treatment was started, 18 of the group A patients and 17 of the group B patients had died, and Table 8 shows that the death rate during this period was similar in the two groups.

TABLE 8
NUMBER OF DEATHS OVER FIVE YEARS

Treatment Group		No. of Treatments Completed				
		1+	101+	201+	301+	401+
A.	No. of patients	60	43	35	24	13
	No. dying	18	7	4	2	1
B.	No. of patients	60	43	31	15	10
	No. dying	17	8	6	1	0

Thirty-five patients died within five years of starting treatment and in general the pulmonary pathology of those coalworkers and pottery workers who came to necropsy conformed with the general findings of Gough (1947) and Meiklejohn (1949).

Post-mortem reports were obtained for 24 of the 30 patients who died and summaries of these are listed in Appendix II, but histological reports on the lungs are only available for nine patients (three group A and six group B). Pulmonary tuberculosis, coexisting with pneumoconiosis or silicosis, was recorded on five of the 24 post-mortem reports : two were group A patients and three group B patients. Only one patient out of the original 120 patients showed signs of active tuberculosis during life : this patient had been included in the investigation with some misgiving and allotted to group B, and he became sputum positive after some three months of treatment and was excluded from further treatment.

The lungs were obtained for examination in nine of the patients and were examined by Professor J. Gough. It is unfortunate that the lungs of only three patients in group A were obtained for post-mortem examination ; two were men who only had some 20 treatments with aluminium dust, then lapsed and died two or three years later : on examining these lungs Professor Gough could not find any increase in the aluminium content after staining the lungs with aluminum (Irwin, 1955). Similarly in the third man who had some three years' treatment (356 aluminium inhalations), there was no evidence of increased aluminium in the lungs. This finding might be explained by the fact that the man had not received any aluminium treatment for the two years before his death.

The lungs of the six group B patients that were obtained for sectioning did not show any features of special interest.

Discussion

A number of clinical investigations have been reported in the literature, which suggests that the therapeutic inhalation of aluminium dust is beneficial. Crombie, Blaisdell, and MacPherson (1944), who made the first of these investigations, carried out therapeutic trials on some 30 patients over a period of a year, reasoning that if one could improve patients with silicosis by means of aluminium therapy, then one would expect that aluminium would be effective as a preventive measure. They treated 36 patients and reported that 19 of them were better clinically, though there was no radiological evidence of improvement. Hannon (1944) found symptomatic improvement in 135 men with radiological evidence of silicosis and disability out of a total of 143. He found that following treatment their disability was reduced and that symptoms of cough, tightness of the chest, and general lassitude improved, and that most patients gained weight. Bamberger (1945), studying 49 non-ferrous metal workers, also reported considerable symptomatic improvement in patients treated with metallic aluminium and hydrated alumina. In none of these trials was there an adequate control group.

The trial most comparable to the one reported here was carried out by Berry in 1948, who treated 26 silicotics with aluminium and nine control silicotics with a placebo for roughly 12 months. He found a subjective improvement in both groups, but no objective change in either group, and he concluded that the symptomatic improvement was psychological in origin. The evidence of the present controlled trial fully supports his findings as there is little to choose between groups A and B as regards the changes in any of the indices measured. Over 50% of patients in both group A and B claimed at nearly all stages of the investigation an improvement in their general condition in one way or another. However, the proportion of patients claiming this improvement was very similar to the proportion claiming improvement after breathing air for six weeks. In Appendix III the change in the mean V.C., M.V.V., and the clinical grade is given for those patients who claimed dyspnoea to be improved, unchanged, or worse after three years of

treatment. Those patients claiming dyspnoea to be improved had deteriorated slightly more as regards their clinical grading than the patients claiming dyspnoea to be unchanged. The effect is small and probably the result of random errors in the assessments, but it may be the result of a change in attitude to breathlessness or the outcome of a sympathetic approach to their problems during the course of the trial. If this were so, it follows that the accurate assessment of changes in chronic diseases must depend on relevant objective measures. Although in this investigation both groups claimed symptomatic improvement there was no evidence to suggest that group A fared any better than group B as regards improvement of functional capacity, the retardation of the progression of established radiological changes, or expectation of life.

Osmond (1955) has summarized the changes in the physiological assessment of 289 foundry workers given aluminium inhalations over a period of six years. Of the 125 men starting aluminium treatment with functional impairment (using the V.C., M.V.V., maximum tidal volume, and pulmonary reserve as measures), 9% deteriorated and 90% were improved after six years. The learning factor, which has been suggested as the cause of the progressive rise in the pre-treatment values of the V.C. and M.V.V. recorded in the present report, may well be responsible for at least some of the improvement described by Osmond. When matters of compensation are at stake, it is only human nature for a patient to be rather slow in learning ! It may be that this learning factor was in part also responsible for the favourable findings described by Hannon (1953) who reported a substantial increase after four months' aluminium therapy in the mean V.C. and M.V.V. values of 46 men which he attributed to the relief of bronchospasm. In the present investigation there was no evidence to suggest that aluminium inhalations relieved bronchospasm, but there was evidence that the expiratory flow rate of patients was reduced immediately following a 15 minutes' inhalation (Kennedy, unpublished data), which is in accord with the suggestion by Lent (1950) that there is often increased bronchospasm following the inhalation of dust.

This trial was designed to show the effect, if any, of aluminium dust inhalation on established cases of pneumoconiosis in potters and coalworkers ; from its clear-cut results it cannot be concluded that aluminium dust given prophylactically to men exposed to a quartz hazard will be equally ineffective. King, Wright, Ray, and Harrison (1950) have made further animal investigations using the inhalation technique : one series of rats was exposed to a cloud of quartz with 2% metallic aluminium powder, and another series was exposed to pure quartz powder. At intervals the animals were killed and the lungs examined. It was found that the animals treated with quartz and aluminium showed evidence of lung fibrosis, but that this fibrosis was only minimal and took much longer to develop than that which occurred in the rats treated with quartz alone. Whatever the reason for the difference between the findings of King and others and those of Denny, Robson, and Irwin (1937), both sets of findings would support the suggestion that aluminium may be valuable for the prophylaxis of silicosis.

A trial of the prophylactic use of the same aluminium dust was started in the Cornish tin-mines by the Medical Research Council in October, 1946. Unfortunately, after it had been running some time it was clear that the administrative difficulties of ensuring a satisfactory control group for a sufficient period were insuperable and the trial was stopped.

Recently Hannon (1953), in a trial of aluminium therapy by inhalation lasting over 11 years in a refractory plant, claimed that none of the 11 treated men showed any radiological abnormality whereas 11 of the 12 controls developed " nodulation ". However, no details of the dust exposures of the two groups are given. Campbell (1953) in a review of the incidence of certified cases of silicosis that occurred before and after the institution of " change room " aluminium therapy, has also reported evidence in support of the prophylactic theory. Parkinson (1955), reviewing data similar to that reported by Campbell, suggests that aluminium prophylaxis may have been a factor in reducing the silicosis incidence. However, he emphasizes the importance of good ventilation and the vigorous dust control measures that have been continuously improved in the Ontario gold mining area since 1926. It is to be hoped that further reports of the progress of these interesting investigations will include an account of the dust hazard to which the treated and untreated workers have been exposed, both before and during the period of observation and treatment with aluminium.

Gardner and others (1944) reported that the inhalation of high concentrations of aluminium hydroxide in animals unfavourably influenced resistance to tuberculosis, and it was this finding that gave rise to the statement in 1946 by the Council on Industrial Health of the American Medical Association that large amounts of aluminium powder might lower the resistance of patients

to tuberculosis. For this reason special precautions were taken to exclude from this trial patients who might have coexisting pulmonary tuberculosis. During and after treatment only one group B patient developed open pulmonary tuberculosis, and the analysis of the deaths, the post-mortem reports, the bacteriological reports on the sputa, and the E.S.R. findings provide no evidence to suggest that inhalations of metallic aluminium at the dose level employed in this investigation favour the development of tuberculosis.

Summary and Conclusions

A controlled trial of aluminium inhalations in the treatment of pottery workers' and coalworkers' pneumoconiosis has been carried out over four years.

One hundred and twenty patients were selected to meet certain criteria and were then separated by pairing into two equal groups comparable as regards age, sex, industrial history, and the manifestations of the disease. The individuals were then randomly allocated to the two forms of treatment.

Group A received pure metallic aluminium dust and group B pure carbon (powder) with the addition of 1 p.p.m. pure metallic aluminium powder. Both groups were given 15-minute inhalations three times each week for as long as three and a half years (or for such less time as the patient continued in the trial).

All subjects were assessed before treatment and during the first, second, third, and fourth years of treatment, and were found to run a parallel course. A major proportion of both groups claimed symptomatic improvement, but the number was only slightly more than those claiming improvement after breathing (unknown to the patient) pure atmospheric air from the cabinets for six weeks. There was no regression of the radiological picture, nor was there objective evidence of improvement in the functional capacity of patients as judged from the results of the exercise tolerance test, the vital capacity, and the maximum voluntary ventilation.

Although there was symptomatic improvement of a general nature in both groups, it is concluded that this improvement was mainly psychological in origin and that the specific inhalation therapy did not produce either any regression in the established disease or an improvement of the patients' functional capacity.

There was no evidence that the aluminium inhalations favoured the development of pulmonary tuberculosis in patients with coalworkers' or pottery workers' pneumoconiosis.

The Industrial Pulmonary Diseases Committee of the Medical Research Council have considered Dr. Kennedy's report on his controlled trial of aluminium therapy and agree with his conclusion that the treatment had no effect either on the symptoms or on the radiological progression of silicosis and pneumoconiosis. They do not recommend the adoption of this method of treatment.

It would have been impossible to launch and complete a long investigation of this type without much help from many sources and people. I should particularly like to thank members of the Aluminium Sub-Committee for encouragement and criticism, and also members of the Pneumoconiosis Research Unit for help in many ways, but particularly Dr. B. M. Wright for devising the means of administering aluminium powder and for his contribution to this report; Dr. J. C. Gilson and Dr. P. Hugh-Jones for advice on the physiological tests, and Mr. P. D. Oldham for statistical help; Drs. A. L. Cochrane, Idris Davies, T. W. Davies, C. M. Fletcher, R. E. Steiner, and A. C. Penman for reading *x*-ray films; the Board of Governors of the North Stafford Royal Infirmary for providing accommodation for the Treatment Centre; the staff of the North Stafford Royal Infirmary for their constant help, but in particular Dr. A. J. McCall, Dr. D. C. Thursby-Pelham, and Dr. Bellamy and Mrs. Mosely; also Colonel R. Phease, Director of the Medical Research Council's Public Health Laboratories, Stafford; Professor J. Gough, of the Welsh National School of Medicine, for pathological investigations; Dr. A. Meiklejohn and Dr. W. W. Jones, of the Stoke-on-Trent Pneumoconiosis Medical Panel, for advice concerning silicosis in pottery workers; Dr. J. Knott for his clinical assessments at yearly intervals; Mr. T. E. Bromley, S.R.N., charge nurse, and Mr. L. Drury, Secretary to the Treatment Centre; the Potters Insurance Co. Ltd., and the National Union of Pottery Workers for their practical help in initiating the Treatment Centre; the McIntyre Research Foundation for supplies of aluminium powder.

Additional Tables of detailed results may be obtained from the Director, Pneumoconiosis Research Unit, Llandough Hospital, near Penarth, Glamorgan.

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APPENDIX I

Administration of Aluminium Aerosol

By B. M. WRIGHT

A review of the previous methods for administering dust by inhalation suggested that none of them was entirely satisfactory. Tumble mills are inconvenient and noisy ; also methods in which previously prepared dust was dispersed into chambers were inconvenient owing to the size of the chamber necessary to store the volume of aerosol required, and to allow a number of men to breathe in and out without building up an undue carbon dioxide tension. Both methods also suffered from the disadvantage that it was difficult to control the dose administered with sufficient accuracy.

Use was therefore made of a technique developed for exposing animals for long periods to controlled concentrations of airborne dust (King and others, 1950), in which dust is fed by means of a special mechanism (Wright, 1950) into an air stream which is blown into a chamber. This gives satisfactory control of concentration and a supply of fresh air for breathing.

Since it would not be convenient to use a chamber large enough to contain the men, a small cabinet with breathing tubes and mouthpieces was used. To prevent large changes of pressure which would result if all men inhaled simultaneously, the chamber was fitted with a spirometer bell, which gave it a variable capacity.

The arrangement is shown diagrammatically in Fig. 1.

The apparatus consists of a cylindrical container (1) of galvanized iron with a detachable conical top (2). On the top of the cone is fixed a platform (4) on which rests a dust-feed mechanism (3) with its nozzle protruding through the platform. The mechanism is connected to compressed air by a rubber pipe (5), and to a 200 volt A.C. by the lead (6). Four outlet nozzles (7) in the sides of the cylinder are connected by means of lengths of concertina tubing (9) to rubber mouthpieces (10), which are fitted with valves so that the subjects can only inhale from the chamber, and exhale to the outside air. Thus the cabinet is not liable to be contaminated, and the mouthpieces and valves can be removed and sterilized. The lower part of the cylinder is filled with water and an air outlet (11) protrudes above the water level ; this is covered with a galvanized iron bell (12) suspended by a string (14) from a grooved pulley (13). The weight of the bell is taken by a helical spring (15) secured to the fixed axle round which the pulley rotates. The tension of the spring is adjusted so that the bell comes to rest at the middle of its range, but can be moved through the whole of its range without producing any appreciable resistance to breathing.

The apparatus is mounted on a ring stand (16) fitted with three castor wheels (17). As the appearance of the dust feed mechanism differed slightly according to the composition of the dust administered, a metal cover (18) was placed over it to conceal it.

In use, air was blown in through the mechanism at 40 l./min., and escaped through the nozzles (7) to the mouthpieces. This rate of flow was sufficient for the average respiratory volumes of four subjects. Fluctuations in air consumption were absorbed by the bell.

The apparatus and its method of use are shown in Fig. 2.

The rate of feed of the mechanism (for the treatmen

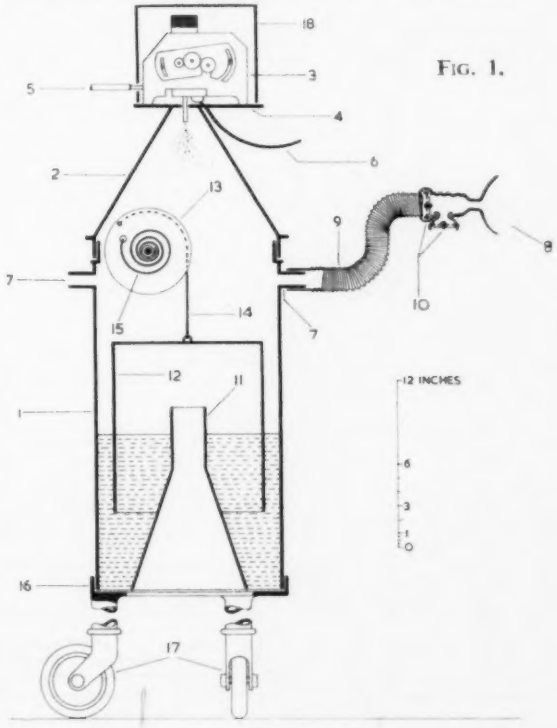

FIG. 1.

FIG. 2.

of group A patients) was adjusted by trial and error until a filter paper sampler, aspirating at 10 l./min. through the inlet valve of a mouthpiece, collected on the average 50 mg. of dust in 15 minutes. Once the mechanism was set it was found possible to check the concentration sufficiently accurately by means of a filter paper and hand pump (Watson and Hounam, 1948), using visual assessment of stain intensity.

The compressed air was supplied by means of a Northey rotary blower, operating without lubrication of the compression chamber, at a pressure of 15 lb./sq.in. This discharged into a reservoir of about 2 cu. ft. capacity, filled with water cooling coils to condense moisture. The reservoir was connected through a short length of rubber hose (to prevent transmission of noise) to piping in the room where there were three air points, each with a flowmeter and control valve.

The whole arrangement worked well over a period of 42 months, with on the average about 150 quarter-hour treatments every week. The dust-feed mechanisms gave no trouble with aluminium dust, though they worked rather less well with the mixed carbon dust and aluminium, probably because of the lower feed rate.

APPENDIX II

SUMMARY OF POST-MORTEM FINDINGS IN GROUPS A AND B

Case No.	Sex	Date of Death	Post-mortem Findings	No. of Treatments
Group A				
9	M	28. 1.53	Haemorrhagic pericarditis (? influenzal), pneumoconiosis	503
8	M	*21.10.53	Lobar pneumonia, silicosis, coronary arteriosclerosis	356
69	M	—	—	241
83	M	31. 1.51	Silicosis with tuberculosis	265
140	M	22. 4.52	Cardiac failure, myocarditis, arteriosclerosis, silicosis	182
28	M	28. 3.51	Acute congestive heart failure, chronic interstitial nephritis, silicosis	152
95	M	23. 1.53	Acute cardiac failure, cachexia, dust reticulosis and silicosis	140
110	M	—	—	<100
107	M	—	—	<100
120	M	—	—	<100
74	M	18.10.49	Heart failure, arteriosclerosis, silicosis	<100
34	F	—	—	<100
91	M	16. 6.51	Silicosis	<100
66	M	*6. 2.52	Cor pulmonale, advanced silicosis, and emphysema	<100
13	M	21. 4.51	—	<100
149	M	*8. 5.51	Silicosis and pulmonary tuberculosis	<100
150	M	26. 1.51	Silicosis	<100
168	M	9. 1.51	Bronchial carcinoma, miners' pneumoconiosis	<100
Group B				
104	M	*16.10.51	Angina pectoris aggravated by pneumoconiosis	334
32	F	4.11.52	Congestive heart failure, emphysema, silicosis	261
55	F	*12.12.51	Silico-tuberculosis	252
105	M	24. 2.41	Pericarditis, infective T.B., silicosis	243
45	M	*10. 5.51	Silicosis	205
26	M	7.12.52	Myocardial degeneration, chronic bronchitis, silicosis	246
130	M	*21. 4.51	Congestive cardiac failure, silicosis and emphysema	145
70	M	* 8. 2.52	Acute oedema of the lungs, acute bronchitis, silicosis	139
23	M	—	—	<100
7	M	7. 5.50	Bronchial carcinoma	<100
62	F	—	—	<100
50	M	—	—	<100
94	M	25.11.50	Silicosis	<100
108	—	—	—	—
109	M	*11. 3.53	Renal adenocarcinoma, silico-tuberculosis	<100
148	M	19. 1.50	†Cardiac failure, pulmonary emphysema, chronic bronchitis	<100
170	M	28.10.50	Cardiac failure and pulmonary oedema due to silicosis	<100

* Lungs obtained for examination. † Bronchiectasis—chronic right aortic valvular disease.

APPENDIX III

Symptomatic Change Related to Change in M.V.V., V.C., and Clinical Grade after Three Years' Treatment

The summary (Table) of average changes shows that after three years of treatment those patients who claimed that their dyspnoea had improved had deteriorated most on the basis of clinical grading. Conversely, those who claimed that their dyspnoea was worse had, on the basis of clinical grading, deteriorated least.

As regards the changes that occurred in the M.V.V. and V.C. values, there is little to choose between patients claiming improvement of dyspnoea and those claiming no change, though there is a comparatively greater drop in the M.V.V. and V.C. values of those claiming dyspnoea to be worse.

The five women irrespective of their subjective symptomatic change showed an average increase of 6·9 l. min. in the M.V.V., but very little change in the V.C. and clinical grade of dyspnoea. These findings, which are at variance with the general downward trend of the M.V.V. and V.C. with advancing age as shown by Gilson and Hugh Jones (1949) and in this report, probably reflect the greater reluctance of women to undergo assessment on a spirometer and hence the longer time they require to learn to perform the tests effectively.

AVERAGE CHANGE IN VALUES AFTER THREE YEARS' TREATMENT RELATED TO DYSPNOEA

Remarks	No. of Patients	Group	M.V.V. (l. /min.)	V.C. (litres)	Clinical Grade*
Patients claiming dyspnoea improved	11	A	−5·5	−0·38	+0·7
	10	B	+1·2 } −2·2	−0·27 } −0·33	+0·45 } +0·6
Patients claiming dyspnoea unchanged	11	A	−2·4	−0·28	+0·4
	4	B	+2·2 } −1·2	−0·53 } −0·35	+0·4 } +0·4
Patients claiming dyspnoea worse	2	A	−8·3	−0·65	+0·5
	1	B	−4·0 } −6·8	−0·67 } −0·66	nil } +0·3
All women irrespective of symptomatic change ..	5	A	+6·9	Nil	+0·2

* An increase in the clinical grading indicates deterioration.

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DEATH RATES OF MINERS AND EX-MINERS WITH AND WITHOUT COALWORKERS' PNEUMOCONIOSIS IN SOUTH WALES

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At present the only practical method by which a diagnosis of coalworkers' pneumoconiosis can be made in life is by means of chest radiographs. Such a diagnosis, however, merely signifies the presence of radiological abnormalities due to exposure to coal dust. Of itself, it can tell us little about pulmonary disability or future loss of expectation of life. It is thus unfortunate that the radiograph has become practically of such importance, both in relation to dust suppression and to industrial compensation, before the necessary correlations have been established, *i.e.*, between dust concentration, time of exposure, and rate of appearance of radiological abnormality on the one hand, and the radiological category of coalworkers' pneumoconiosis, age, pulmonary disability, and loss of expectation of life on the other.

Roach (1953) has shown that a relationship exists between dust concentration, time, and the appearance of the first radiological abnormalities. Gilson and Hugh-Jones (1955) and Gilson, Higgins, and Carpenter (1956) discuss the relationship between age, radiological category, and pulmonary disability. This paper attempts the third of these correlations—the relationship between age, radiological category, and expectation of life.

The problem has been much misunderstood in the past amongst both doctors and laymen. The radiological changes in coalworkers' pneumoconiosis are particularly striking, and some doctors who tend to judge these changes by comparing them with tuberculosis, with which they are better acquainted, have sometimes given too gloomy a prognosis. Moreover, people have an understandable difficulty in differentiating between figures relating to those suffering from coalworkers' pneumoconiosis who die and figures relating to those who die from pneumoconiosis. The publicity given to the former figures and the lack of information about the latter have probably given an exaggerated picture of the seriousness of the disease from the point of view of mortality.

The literature on the effect of pneumoconiosis on mortality is somewhat limited. Fletcher (1948) pointed out that the standardized death rates of coal-miners in England and Wales for all respiratory diseases except tuberculosis, when compared with those rates for all occupied and retired males, showed a marked excess for the four periods 1900–02, 1910–12, 1921–23, and 1930–32. He also pointed out that it was the coal-miners over the age of 55 in whom this excess of deaths was seen and suggested that this excess of deaths might be due to deaths from coalworkers' pneumoconiosis. The only detailed study of death rates associated with coalworkers' pneumoconiosis is that of Stewart, Davies, Dowsett, Morrell, and Pierce (1948). They followed up 3,435 coal-miners who had been certified during life by the Silicosis Medical Board in South Wales during the period 1931–45. Their analysis suggested that for both the "early disease" group and the "advanced disease" group there was a marked reduction in survival rate as compared with the 1931 English Life Table, No. 10 (Registrar General, 1936). After 10 years it appeared that 60% of those with "early disease" and 25% of those in the "advanced" group might still be alive compared with 85% expected from the life table. This suggested that coalworkers' pneumoconiosis was associated with a marked loss of expectation of life.

Ideally, to study this problem one requires a very large complete population of miners and ex-miners,

all of whom have been radiographed, in an area with a high prevalence of all types of coalworkers' pneumoconiosis. In addition, one needs another complete population of similar social class who have not been exposed to coal dust. The size of the population should be such that there would be sufficient deaths within one year of the radiological survey to give a clear-cut answer to the problem. The short follow-up is important since difficulties arise through people leaving the area and becoming increasingly difficult to trace.

It is highly improbable that such material will ever be available and so, as the problem is important, one is forced to see what can be deduced from the best material that is available.

Material

The population of the Rhondda Fach (a mining valley in South Wales with a population of about 30,000) was surveyed first in 1950–51, when 89% of those over the age of 5 in the valley were radiographed (Cochrane, Cox, and Jarman, 1952). In 1953 the valley was re-surveyed, 91% radiographed, and particular care was taken to see what had happened to all those who were in the valley at the time of the first survey (Cochrane and others, 1955). As a result, we have a population in 1950–51 carefully defined by age and sex, the males divided into miners, ex-miners, and non-miners, and the miners and ex-miners further classified according to their pneumoconiosis category (Cochrane, Davies, and Fletcher, 1951 ; Cochrane, Fletcher, Gilson, and Hugh-Jones, 1951 ; Fletcher, 1955), together with deaths in the various groups during the interval between the two surveys. The average interval between the two surveys was determined by examining the dates of a random sample of films and was estimated as 2·6 years.

The material is not ideal. In the first place it is too small. This means that the life table approach is not possible as the procedure for comparing life tables based on small numbers has not been developed. Hence the analysis is confined to a study of observed and expected death rates. In addition, only about 95% of the miners and ex-miners were radiographed, and illness was of course one cause for failure to be radiographed. Even after a follow-up of two and a half years when difficulties in tracing people were beginning to become apparent, there were too few deaths to justify a breakdown by cause. This was, however, a minor drawback, as we were mainly interested in total effect on life and not in the mode of death of pneumoconiotics, or in how a decrease from one cause could be balanced by an increase in another.

We also had no ideal control group. The non-miners in the valley are a very small group, their numbers being particularly deficient at higher ages. We have therefore used the only other material available, the Registrar General's data for England and Wales. This is the usual standard used in calculating standardized mortality ratios. The data for England and Wales have the advantage that numbers of deaths are so large that the random errors in the expected number of deaths calculated from them can be ignored.

Our material is, however, clearly unsuitable for direct comparison with the Registrar General's figures. The latter's material consists of deaths in one year in a large complete population related to the mid-year population estimates ; our material consists of deaths during a period of 2·6 years occurring in a relatively small population defined at the beginning of the period. It is clear that the population gets older and certain small changes take place in radiological category during the period of the follow-up. The radiological changes are few in number and can be ignored for the purposes of this study, while, to compare the experience of the Rhondda Fach with the national mortality experience during the follow-up period, we have worked out, from the Registrar General's published figures, the number of deaths that would have been expected in the Rhondda Fach. The method of obtaining these figures is given in the Appendix. To compare the observed with the expected number of deaths over a specified age range, we used standardized mortality ratios (S.M.R.) which are the observed number of deaths expressed as a percentage of the number expected on the basis of national age-specific rates.

Results

Table 1 gives the age and sex distribution of the population of the Rhondda Fach at the time of the first radiological survey, together with the observed

TABLE 1

DEATHS (ALL CAUSES) OBSERVED AND EXPECTED AMONGST MALES AND FEMALES IN THE RHONDDA FACH IN 1950–51

Age	Males			Females		
	No.	Observed Deaths	Expected Deaths	No.	Observed Deaths	Expected Deaths
5–	975	2	1·5	1,000	1	1·1
10–	1,010	4	1·5	1,005	2	1·0
15–	891	5	2·2	972	4	1·5
20–	819	5	2·8	887	7	2·0
25–	1,890	19	7·9	2,018	11	6·7
35–	1,798	22	14·9	1,878	8	11·8
45–	1,557	46	37·3	1,783	28	26·1
55–	1,326	98	86·1	1,397	54	50·3
65–	823	141	124·0	883	75	86·3
75–	296	108	92·7	332	88	82·9
85–	27	13	15·4	45	25	23·3
Total	11,412	463	386·3	12,200	303	293·0

deaths and the expected deaths, as obtained by the methods shown in the Appendix. It is clear that amongst males the observed number of deaths are somewhat higher than the expected number, but no such differences are apparent for the females. This is confirmed by the standardized mortality ratios for the two sexes (Table 2). This difference between the S.M.R.s of the two sexes at once suggests the possibility of some occupational factor influencing the male death rates.

TABLE 2
STANDARDIZED MORTALITY RATIOS IN THE RHONDDA FACH 1950–51

Age	Males	Females
20–64	190/149·0 = 127·5%	108/ 96·9 = 111·5%
25–74	326/270·2 = 120·7%	176/181·2 = 97·1%
5–74	342/278·2 = 122·9%	190/186·8 = 101·7%

Before, however, examining the death rates in relation to pneumoconiosis category, a possible major source of error must be considered. It was not possible to radiograph every male, and as illness was one reason for not being radiographed it is possible for a considerable error to creep in. The "observed" and "expected" deaths for radiographed males and males not radiographed are shown in Table 3 together with their S.M.R.s and their standard errors. It will be seen that the S.M.R.s for those not radiographed are appreciably higher than those for the radiographed. Although we have a great deal of information about those who were not radiographed and corrections can be introduced to make allowance for them, we considered it more correct to present the results obtained from the radiographed population first before dealing with the corrections.

Table 4 shows the age distribution of the four male groups who were radiographed: (1) those who had never been miners; (2) the miners and ex-miners whose radiographs were normal as regards coalworkers' pneumoconiosis; (3) the miners and ex-miners whose radiographs showed simple pneumoconiosis (categories 1, 2, or 3) or complicated pneumoconiosis (category A); (4) those miners and ex-miners whose radiographs showed advanced complicated pneumoconiosis (categories B, C, and D). In addition, Table 4 shows the expected and observed deaths for the various groups. Complicated pneumoconiosis (category A) has been included with the group of those with simple pneumoconiosis as at this stage simple pneumoconiosis is still likely to be the predominant feature from the physiological point of view. This is confirmed by physiological studies (Gilson and others, 1956). A further reason for this grouping is the fact that tomography of those with category 2 or 3 on postero-anterior films occasionally reveals areas of complicated pneumoconiosis.

Table 5 shows the S.M.R.s calculated for various age ranges of the various occupational radiological groups. It seems reasonable, when dealing with a condition like coalworkers' pneumoconiosis, to attach more importance to the age range 35–74

TABLE 3
STANDARDIZED MORTALITY RATIOS OF MALES IN THE RHONDDA FACH

Age Range	All Males				Males Radiographed				Males not Radiographed			
	Observed Deaths	Expected Deaths	S.M.R.	Standard Errors	Observed Deaths	Expected Deaths	S.M.R.	Standard Errors	Observed Deaths	Expected Deaths	S.M.R.	Standard Errors
20–64	190	149·0	127·5	±9·25	168	136·9	122·7	±9·47	22	12·1	181·8	±38·76
25–74	326	270·2	120·7	±6·68	272	239·0	113·8	±6·90	54	31·2	173·1	±23·55
5–74	342	278·2	122·9	±6·65	288	246·4	116·9	±6·89	54	31·8	169·8	±23·11

TABLE 4
OBSERVED AND EXPECTED DEATHS AMONGST NON-MINERS AND MINERS AND EX-MINERS WITH AND WITHOUT PNEUMOCONIOSIS IN THE RHONDDA FACH

Age	Non-miners			Miners and Ex-miners								
				Category 0			Categories 1, 2, 3, and A			Categories B, C, and D		
	No.	Observed Deaths	Expected Deaths	No.	Observed Deaths	Expected Deaths	No.	Observed Deaths	Expected Deaths	No.	Observed Deaths	Expected Deaths
15–	549	2	1·4	273	3	0·7	4	—	—	—	—	—
20–	453	2	1·6	271	3	0·9	44	—	0·2	1	—	—
25–	669	6	2·8	686	5	2·9	382	6	1·6	25	—	0·1
35–	405	4	3·4	630	3	5·2	522	10	4·3	121	3	1·0
45–	187	3	4·5	669	21	16·0	462	10	11·1	137	5	3·3
55–	126	7	8·2	541	40	35·1	362	26	23·5	176	14	11·4
65–	53	8	8·0	300	46	45·2	222	30	33·4	120	25	18·1
75–	17	8	5·3	91	27	28·5	49	16	15·3	40	12	12·5
Total	2,459	40	35·2	3,461	148	134·5	2,047	98	89·4	620	59	46·4

TABLE 5

STANDARDIZED MORTALITY RATIOS FOR NON-MINERS AND MINERS AND EX-MINERS WITH AND WITHOUT PNEUMOCONIOSIS IN THE RHONDDA FACH

Age Range	Non-miners				Miners and Ex-miners											
					Category 0				Categories 1, 2, 3, and A				Categories B, C, D			
	Observed Deaths	Expected Deaths	S.M.R.	Standard Error	Observed Deaths	Expected Deaths	S.M.R.	Standard Error	Observed Deaths	Expected Deaths	S.M.R.	Standard Error	Observed Deaths	Expected Deaths	S.M.R.	Standard Error
20–64	22	20·5	107·3	±22·88	72	60·1	119·8	±14·12	52	40·7	127·8	±17·72	22	15·8	139·2	±29·69
25–64	20	18·9	105·8	±23·66	69	59·2	116·6	±14·03	52	40·5	128·4	±17·81	22	15·8	139·2	±29·69
25–74	28	26·9	104·1	±19·67	115	104·4	110·2	±10·27	82	73·9	111·0	±12·25	47	33·9	138·6	±20·22
35–74	22	24·1	91·3	±19·46	110	101·5	108·4	±10·33	76	72·3	105·1	±12·06	47	33·8	139·1	±20·28

than to the others, and on this basis one would say that there was no evidence that simple pneumoconiosis was associated with a decreased expectation of life. Some evidence of a trend is apparent here but before accepting it we need to examine the separate age groups in more detail. Standardized mortality ratios could be derived for each of the age-occupation-radiological groups shown in Table 4, but since the standard errors depend both on the chance of dying and on the number of people in the group, each of these S.M.R.s would require a separate standard error to assess its significance.

A transformed death rate ψ* can be derived for each of the four occupational radiological groups at relevant ages (Table 6), which does not have this disadvantage. The value of ψ is positive if the observed number of deaths in the group is greater than expected, zero if equal to expected, and negative if less than expected. Each ψ has the same standard error of ±28·7†. Thus a single observation of ψ which is greater than 57·4 indicates a significant excess in the observed number of deaths, and similarly an observation which is less than −57·4 indicates a significant reduction in the observed number of deaths in comparison with the expected number. This makes visual inspection of a table of death rates, for values which are likely to be significant, very easy, although in a large table of entries, such as Table 6, one or two apparently significant entries are to be expected by chance alone.

The following points emerge from Tables 3, 4, 5, and 6 :—

(1) The observed number of deaths among all males over 25 who were radiographed is above expectation. The S.M.R. of the group is 113·8 ± 6·90 and this excess is confirmed as being significant in that the overall mean of ψ in Table 6 is significantly greater than zero. This is not due to an excess of deaths in one group alone.

(2) Increasing radiological category seems to show a trend of increasing S.M.R. but from the values of ψ in Table 6 we see that there is no definite trend of this sort in any of the age groups.

(3) Table 6 also shows that in none of the occupational radiological groups does the observed number of deaths increasingly exceed the expected number, with increasing age.

(4) Among non-miners the number is mainly near that expected, with insignificant excesses in the youngest and oldest age groups.

(5) Among those with early pneumoconiosis an excess occurs in the two youngest age groups. The number of deaths in both these groups exceeds the values expected by chance in a single observation, and it is unlikely that a pair of values as large as these would occur by chance in the same occupational radiological group and in adjoining age groups anywhere in Table 6. It therefore appears that in these two age groups the radiological changes are associated with some increased risk of death, but the risk is almost certainly not caused by the pneumoconiosis.

In the first place, the non-miners and the category 0s show an excess of observed deaths over expected

TABLE 6

TABLE OF TRANSFORMED DEATH RATES ψ CORRESPONDING TO TABLE 4

Age	Non-miners	Miners and Ex-miners		
		Category 0	Categories 1, 2, 3, and A	Categories B, C, and D
25–	44·0	28·8	68·4	—*
35–	10·1	−27·6	61·7	42·9
45–	−23·3	31·0	−8·6	23·4
55–	−11·2	23·3	15·2	22·6
65–	0	1·7	−19·4	47·1
75–85	38·7	−9·5	6·3	−5·1

Overall mean of ψ = 15·7 ± 5·97. Theoretical standard error of ψ = ±28·7.

* The transformation is not useful when the observed number of deaths is zero.

* $\psi = \sqrt{n}(\sin^{-1}\sqrt{p} - \sin^{-1}\sqrt{q})$ where n = number of subjects followed up, p = observed percentage of deaths, and q = expected percentage of deaths.

† Strictly the standard errors of ψ are only constant if in each age-occupation-radiological group each individual has the same chance of dying in the inter-survey period. In this case the standard error would be ± 28·7 as stated. The observed standard error is almost identical with the theoretical value, being ±27·04, so that the theoretical model seems to fit the data well, and the theoretical standard error has been adopted.

in those aged 25 to 34. In the second place, the group of those category 1 to A consists largely of working miners at special risk to pit accidents. In fact, of the 16 deaths in this group under the age of 45, five were from violent causes, four being due to pit accidents. But against this must be set the fact that in 1953 22% of deaths in England and Wales of those aged 25 to 44 were from violent causes. This illustrates the difficulty of any attempt to restrict the study to specific causes of death, in that both the observed deaths and the national death rates have to be purified. Table 5 shows that the S.M.R.s for those with early pneumoconiosis are not raised to any significant extent.

(6) There is an excess in all but the last age group among those with B, C, and D radiographs. The excess is not significant in any of the age groups individually, nor is the excess significant when all the age groups are taken together, as the S.M.R.s in Table 5 also show, and this can be confirmed by the occupational radiological group means calculated from the ψ in Table 6.

The following information is available about those who were not radiographed at the time of the first survey :—

(1) Their age was obtained by home visiting at the time of the first survey.

(2) Their occupation was determined in two towns in the valley at the first survey, and of those remaining in all the eight towns at the time of the second survey. The proportion of non-miners to miners and ex-miners in corresponding age groups was almost identical in these two samples.

(3) The radiological category of 56% of them was obtained at the time of the second survey.

The age distribution of the lapses is unfortunate in that the lapse rates are highest in those age groups most likely to be affected by pneumoconiosis, and Table 3 shows that the number of deaths that occurred among them is not negligible. The fact that the two samples showed similar proportions of non-miners to miners and ex-miners is encouraging in that they do not lead us to think that all those lapsing who died were miners or ex-miners, but the comparison is an insensitive one for detecting the occupational group of those who died. Calculations based on those who survived to the second survey and on those who were radiographed then suggest that, for example, of those aged 65 to 74, 15% were non-miners, 46% were miners and ex-miners category 0, 25% were categories 1 to A, and 14% were B, C, or D, with similar percentages in these occupational radiological groups at other ages. Although nothing can replace the missing information concerning the lapses it seemed worth while studying what the effects of the lapses would be were they distributed among the occupational radiological groups as suggested by these data from the second survey, and the deaths that occurred among the lapses distributed in proportions based on this distribution of the lapses in the occupational radiological groups, and the observed death rates for the corresponding groups at the appropriate age. The results of these calculations were to increase the number of deaths in all groups, principally amongst miners and ex-miners category 0, but did not suggest that we ought to modify the conclusions already drawn from the data.

The only other source of information about the lapses that suggested itself was the certified causes of death. Examination of these immediately shows they contain no specific information as to which occupational radiological group the case belonged, except for the occasional case which came to necropsy.

Discussion

These results will be considered by some people as somewhat surprising in that we have found no evidence that simple pneumoconiosis, during the period of observation, was associated with any decreased expectation of life in any of the older age groups. We have not, of course, excluded the possibility of some small increase or decrease in expectation of life. Our results are, however, in agreement with those of Gough and Heppleston (1955) that "simple pneumoconiosis is very rarely fatal".

We have, too, found only suggestive evidence that progressive massive fibrosis is a lethal disease, but this is perfectly compatible with the high prevalence (about 15%) of P.M.F. found in the higher age groups in the Rhondda Fach (Cochrane and others, 1952).

All these results differ strikingly from those of Stewart and others (1948). The extent of the difference is shown in Table 7. Their material consisted of "certified" cases in South Wales during the

TABLE 7

EXPECTED NO. OF DEATHS AMONG MINERS AND EX-MINERS WITH PNEUMOCONIOSIS AGED 50 IN THE FIRST TWO AND A HALF YEARS CALCULATED FROM STEWART AND OTHERS' (1948) FINDINGS AND COMPARED WITH THE FINDINGS FOR CATEGORIES B, C, D, AGED 45–54 IN TABLE 4

	Number of Deaths	Transformed Mortality Index ψ
Rhondda Fach (Observed) ..	5	23·4
England and Wales (Expected) ..	3·3	0·0
Stewart and others { Early stages ..	7·3	51·5
Stewart and others { Advanced stages ..	33·4	242·4

Theoretical standard error of $\psi = \pm 28{\cdot}7$

period 1931–45. It seems possible that a marked bias was introduced into the results by the fact that only very disabled cases, particularly in the early period, could be certified. There is a wide scatter of pulmonary disability in each age group, and selection could produce a considerable difference to the average expectation of life. It is also possible that two other factors may have influenced the case fatality rate of complicated pneumoconiosis in comparatively recent times. Before the use of antibiotics in the treatment of the tuberculous, the prognosis in cases of complicated pneumoconiosis with tubercle bacilli in their sputum was very serious. Theodos and Gordon (1952) stated that 66% were dead in three years, and more recently Kilpatrick, Heppleston, and Fletcher (1954) found that in such cases with radiological signs of cavitation, 75% were dead in three years. In the Rhondda Fach in 1950–51 there were 10 patients with B, C, or D shadows and tubercle bacilli in their sputum of whom only one died in the next 2·6 years. If another seven had died, as seems probable had they not received chemotherapy, the S.M.R.s for this group would have been considerably higher, as shown in Table 8. Similarly, the intensive use of antibiotics in the treatment of the non-tuberculous respiratory

TABLE 8

THE S.M.R.s OF CATEGORIES B, C, AND D, ASSUMING THAT 75% OF SPUTUM-POSITIVE PATIENTS IN CATEGORIES B, C, AND D HAD ALSO DIED

Age Range	Miners and Ex-miners in Categories B, C, and D			
	Observed Deaths	Expected Deaths	S.M.R.	Standard Errors
20–64	29	15·8	183·5	± 34·08
25–64	29	15·8	183·5	± 34·08
25–74	54	33·9	159·3	± 21·68
35–74	52	33·8	153·8	± 21·33

infections, from which the cases with advanced complicated pneumoconiosis so frequently suffer, may also have influenced their case fatality.

As regards simple pneumoconiosis, one point must be stressed to avoid misunderstanding. The higher categories of simple pneumoconiosis are associated with an increased risk of developing complicated pneumoconiosis (Fletcher, 1948, Davies Fletcher, Mann, and Stewart, 1949 ; Mann 1951 ; Cochrane and others, 1951). The rate of appearance of the latter on the former is of the order of 1 to 2% per annum, so there was in our short follow-up of 2·6 years little chance of the mortality associated with simple pneumoconiosis being influenced by those patients who develop the more advanced form of complicated pneumoconiosis. This would not hold good in a long-term follow-up. Our data therefore lead to the following conclusions ; there is no evidence to suggest that on the average a radiological diagnosis of simple pneumoconiosis over the age of 45 carries an increased risk of death within the next two and a half years. Individuals may, of course, be differently affected, but since the above was true for all ages we may say that simple pneumoconiosis would not appear to affect the expectation of life, provided P.M.F. did not develop, and should P.M.F. develop the reduction in expectation of life did not appear to be as marked as has sometimes been thought. Our data do not, of course, exclude the possibility of some small increase or decrease in expectation of life associated with simple pneumoconiosis.

Summary

The deaths from all causes in the Rhondda Fach between the two radiological surveys in 1950–51 and 1953 have been related to the age, sex, and occupation of those in the valley at the time of the first survey and compared with expected values derived from the Registrar General's figures for England and Wales. In the case of miners and ex-miners radiographed during the first survey, the deaths were also related to the category of pneumoconiosis found in their chest radiographs at that time. The results suggest that the more advanced forms of complicated pneumoconiosis, in the higher ages, may be associated with an excessive number of deaths. No such excess was found associated with simple pneumoconiosis, although the possibility of a small excess or deficiency could not be excluded.

This work was carried out under the general direction of the Rhondda Fach Local Advisory Committee and we should like to express our thanks to them for their help, encouragement, and advice. They are not in any way responsible, however, for the views expressed by the authors in this paper.

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APPENDIX

It might be thought that there is nothing very difficult in calculating the expected number of deaths from the Registrar General's annual mortality rates. The changes in the age of the population are small, the death rates fairly constant, and the duration of the follow-up not long. Hence it might be expected that it would be all right to ignore changes in age and the fact that the size of the population followed up decreases with time owing to deaths. But a rough approach which ignores both these changes may give estimates that are too small by 14% of the expected deaths, while if we only ignore the second of these changes we increasingly overestimate the expected number of deaths, as the age of the group increases, so that in the oldest age groups our estimate will be about 50% too large. Obviously such errors must be avoided, and we therefore give an account of the computational procedure adopted and the reasons for it.

The population that we followed up in the Rhondda Fach is divided into age groups by age last birthday on January 1, 1951. The Registrar General tabulates death rates for groups based on age at the mid-year. Thus in 1951 our age groups will be six months older than the corresponding groups for which rates are tabulated. In 1952 they will be one and a half years older and in the first seven months of 1953 2·3 years older. The task of deriving the expected number of deaths in the Rhondda Fach then falls into two stages. The first is to derive the rates in England and Wales for 1951, 1952, and the first 0·6 of 1953 appropriate to our age groups by interpolation. The second stage is to apply these rates to the Rhondda Fach population.

If we plot out the logarithm of the death rates for England and Wales at equal intervals of age, we find that they fall on an approximately straight line. The approximation is good for the higher age groups, *e.g.*, over 25, on which interest is chiefly centred. Below this age the assumption that the log (rates) are linear will not lead us far astray. If, therefore, we require the death rate for a 10-year age group, different from those tabulated, the best way to derive it is by linear interpolation, or for a group older than 85 by extrapolation, on the logarithms of the tabulated rates. Death rates for five-year age groups can be derived similarly when the rates for five-year groups are tabulated.

This procedure of interpolating is based on observation of the behaviour of the tabulated death rates and avoids any assumptions about the proportions of deaths that occur at any particular age. In particular, it avoids assuming that if ν (65–) is the tabulated rate for the age group 65–74 then the proportion of deaths at age 70 is equal to ν (65–), a dangerous assumption which will only be true in special circumstances.

The Registrar General tabulates the total mid-year population and the number of deaths per month in five-year age groups. The death rates are also tabulated in five-year age groups up to the age of 25, thereafter being tabulated in 10-year age groups. Thus, deriving rates for 1951 and 1952 for our age groups is merely a matter of linear interpolation and extrapolation with the logarithms of the tabulated rates. The only difficulty is at the changeover of the interval of tabulation. This is easily surmounted by computing the death rate for the age group 25–30. For 1953, death rates like the usual ones tabulated were worked out, based on the number of deaths in the first seven months of 1953 and divided by the mid-year population. The use of the mid-year population is an approximation which will have a negligible effect on the results. The effective rate of death operating will be this rate divided by 0·6, the portion of the year covered.

Having derived the expected rates for each year, we have to calculate the expected number of deaths in the inter-survey period. To do this we assume the rate of death is constant in each age group throughout each year. This will be fairly accurate as the increase in rate due to age is more than offset by the decrease in rates with time, with the result that the expected rates remain remarkably constant over the inter-survey period.

Consider one such age group. In a small interval of time $\delta\tau$ at τ let

$\rho(\tau)$ = the population alive
$\delta\rho$ = the change in the population
$\nu(\tau)$ = the rate of death at time τ, expressed as a proportion and not as a percentage or otherwise, per unit interval of τ

Note, $\delta\rho$ in this case can only be due to death as all the original population were followed up to find out if they were still living. Then

$$\delta\rho = -\rho(\tau)\,\nu(\tau)\,\delta\tau.$$

Integrating with respect to τ from τ_0 to τ_1 we get :

$$\int_{\tau_0}^{\tau_1} \frac{\alpha\rho}{\rho(\tau)} = -\int_{\tau_0}^{\tau_1} \nu(\tau)\,\alpha\tau$$

$$\log\left\{\rho(\tau_1)/\rho(\tau_0)\right\} = -\nu(\tau_1-\tau_0),$$

if $\nu(\tau)$ is constant and equal to ν in the interval (τ_0, τ_1). That is

$$\rho(\tau_1) = \rho(\tau_0)\exp\left\{-\nu(\tau_1-\tau_0)\right\}.$$

In the case on hand the unit interval of time is one year. We have rates ν_1, ν_2, and $\nu_3/0{\cdot}6$ operating on the group from τ_0= January 1, 1951, to τ_1, = January 1, 1952, τ_1 to τ_2 = January 1, 1953, and τ_2 to τ_3 = August 1, 1953, respectively.

Then

$$\begin{aligned}
\rho(\tau_1) &= \rho(\tau_0)\exp\left\{-\nu_1\right\}\\
\rho(\tau_2) &= \rho(\tau_1)\exp\left\{-\nu_2\right\}\\
\rho(\tau_3) &= \rho(\tau_2)\exp\left\{(-\nu_3/0{\cdot}6)\times 0{\cdot}6\right\}\\
&= \rho(\tau_2)\exp\left\{-\nu_3\right\}\\
\therefore \rho(\tau_3) &= \rho(\tau_0)\exp\left\{=(\nu_1+\nu_2+\nu_3)\right\}
\end{aligned}$$

and the expected number of deaths is equal to

$$\rho(\tau_0)-\rho(\tau_3) = \rho(\tau_0)\left[1-\exp\left\{-(\nu_1+\nu_2+\nu_3)\right\}\right]$$

Thus once the rates ν_1, ν_2 and ν_3 have been derived we obtain the expected number of deaths in each age, sex, or occupation group by multiplication of the population by a factor. Adding the observed and the expected number of deaths for several age groups we can obtain the standardized mortality ratios (S.M.R.) for the inter-survey period for any age range.

Standard Errors

By assuming that the number of deaths each year in England and Wales is a Poisson variable we can compute the standard error of the expected number of deaths in any age group, or for the total number of deaths expected in any population. These expected numbers will be a weighted sum of Poisson variables. For the total female population in the Rhondda Fach, the standard error of the estimate of the expected number of deaths, 293·0, is less than $\pm 0{\cdot}6$ and will be smaller for smaller groups. This is assumed to be negligible.

On the other hand, if we regard the numbers of deaths in each of the age groups that are observed as Poisson variables, the total number of deaths observed for any combination of groups will still be a Poisson variable. Hence we can deduce that the standard error of an S.M.R. will be

$$\pm \frac{\sqrt{(\text{No. of deaths observed})}}{\text{No. of deaths expected}}$$

and by using tables for the Poisson distribution we could test whether the S.M.R. is significantly different from 100.

The assumption that the number of deaths has a Poisson distribution gives an overestimate of the variance of the S.M.R., but is sufficiently accurate to show the orders of magnitude involved, if deaths occur in a random manner, with a given expectation. The validity of this hypothesis is discussed with reference to Table 6, where an alternative treatment of departure from expectation is given.

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MUCOUS FLOW AND CILIARY ACTIVITY IN THE TRACHEA OF RATS EXPOSED TO PULMONARY IRRITANT GAS*

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In the field of occupational hygiene questions frequently arise concerning the effect on the respiratory tract of inhaled gases and of vapours from industrial solvents. The action of such agents is primarily on the mucosa of the respiratory tract.

Any study of this question necessarily involves determination of the rates of mucous flow and ciliary beat and investigations of possible morphological changes. The literature contains a few reports dealing with mucous flow and ciliary activity in various animals, *e.g.*, by Ballenger (1949), Gray (1923), Lucas (1932), and Proetz (1933). Such studies, however, were not systematically carried out and did not pay sufficient attention to important physiological factors such as the temperature and moisture of the tissue examined. Moreover, the great majority of the experiments were performed *in vitro*, a procedure which several writers have strongly criticized (Barclay, Franklin, and Macbeth, 1937; Gordonoff and Mauderli, 1936).

A method devised by Dalhamn (1955), on which a preliminary report has been published, was used in the present study. This is part of a more extensive investigation of relevant questions, which it is intended to publish later in more complete form. For present purposes it is sufficient to say that in 37 healthy rats the mean rate of mucous flow in the trachea was found to be 13·5 mm. per minute and the mean rate of ciliary activity 1,317 beats per minute.

In regard to ciliary movement, however, the frequency of beat is not the only factor of interest. In several reports in the literature it has been stated that the ciliary beat in many lower animals such as mussels and oysters consists of a rapid phase, the " effective stroke ", and a slower " recovery stroke ". The time relationship between the two was given as 1 : 2 to 1 : 5. No study has hitherto been made of the corresponding time ratio in vertebrates.

Investigations of the phases of ciliary movement were made in the present experiments with a special high-speed cinematograph camera, permitting about 1,000 exposures per second. Thus each image was registered within a millisecond. Such rapid registration imposes very great demands on the film material and on the lighting arrangements. When the film is projected one sees, particularly at the edges of the light reflection, a rhythmic flaring up and diminution. From photomicrographs of some of the cinematograph films the time relationship between the rapid flare of the reflex and its gradual diminution was calculated to be approximately 1 : 3.

Rats were subjected to prolonged exposure to SO_2 in the currently accepted maximum allowable concentration, *i.e.*, 10 p.p.m. or 10^{-3} volumes %. Nine rats were so exposed six hours daily for about 10 weeks. Six of the nine were then studied for secretory flow and rate of ciliary beat in the trachea. The three remaining animals were not exposed to SO_2 during the next four weeks.

Immediately the trachea of the exposed rats was opened it was noted that the amount of secretion was greatly in excess of normal and that the mucosa was vascularized and reddened. Study of the mucous flow showed that this had ceased entirely in several cases and in the others was much slower than in normal rats. The mean rate of flow in the six rats was 5 mm. per minute.

The frequency of ciliary beat, on the other hand, seemed unaffected, being similar to that in unexposed rats, *i.e.*, a mean of 1,320 beats per minute.

On first thoughts it may appear contradictory that the secretory flow should slow in the presence of normal frequency of the ciliary beat. This, however, may be explained in several ways. Sjöstrand (1941) pointed out that one may expect

* From a paper read before the Swedish Society of Physiologists on May 6, 1955.

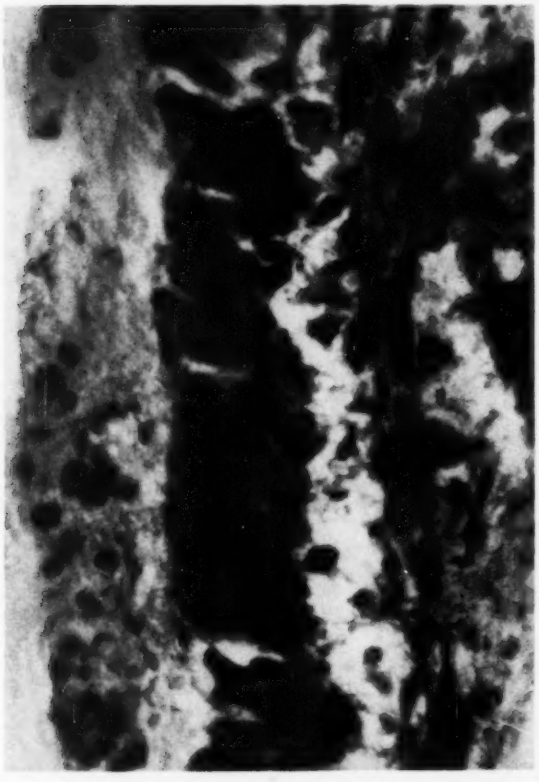


FIG. 1.—Freezed-fixed mucosa from a rat exposed for 67 days to 11·5 p.p.m. SO_2. The mucous blanket is considerably thicker than normal. The secretion contains numerous cellular elements. × 830.

an insignificant flow of mucus if the thickness of the secretory layer is four to five times as great as the length of the cilia. As stated above, the trachea of the exposed animals was immediately seen to contain a greatly increased amount of mucus. It was of interest, however, to obtain an objective measurement of this increase. By using the freeze-dried fixation method described by Sjöstrand (1944) it was possible to demonstrate that the mucosal layer in the trachea of the exposed rats was very much thickened, appeared more compact than normal, and was strewn with shed cells of various types (Fig. 1). In normal rats the thickness of the mucous layer was about 5 μ and in the exposed rats about 25 μ.

Yet it is not only the thickening of the mucosa which may give rise to retardation of the secretory flow when the rate of ciliary beat remains unaltered. The viscosity of the secretion also plays a decisive part. Because of the anatomical and physiological conditions in the trachea of the rat it was found to be extremely difficult to obtain a reliable method for determining the viscosity of the tracheal secretion.

Still another factor which may contribute to slowing the mucous flow is a change in the time relationship of the ciliary phases, involving a levelling effect. Study of the movements of single cilia, however, failed to show any shift in this ratio. The reduced mucous flow in the exposed rats, therefore, would seem to have been primarily attributable to alterations in the viscosity or quantity of the secretion, or to a combination of both factors.

Analogous experiments, with the exception of study of the movement of ciliary phases, were made on the three rats which had been allowed to rest for four weeks following exposure to SO_2. The results were in complete conformity with those in the rats examined directly after exposure. Thus there was still reduced mucous flow of the same order as in animals which had not been rested. The mucosa was reddened and the mucous layer much thicker than normal. Although this latter group was small, the findings in all three rats pointed clearly in the same direction.

The tracheal mucosa was studied after exposure to SO_2 by microscopy and electron microscopy.

Microscopy, both immediately and four weeks after exposure to SO_2, showed severe changes in the tracheal epithelium. This finding has already been reported (Dalhamn, 1955). Both the epithelium and the lamina propria were affected. The epithelium thus showed very long and slender ciliated cells and its surface, which normally is level and smooth, displayed in places very deep crypts. The cilia appeared to be very tightly packed on the surface of the cells.

In the lamina propria the most obvious change was severe oedema, on which the entire epithelium seemed to float freely. In addition there was profuse vascularization and perivascular extravasation of blood. In places the collagen fibrils were split and fragmented (Rhodin and Dalhamn, 1955).

Of the electron microscope studies only those concerning the structure of the cilia will be dealt with here, as these are of the greatest interest in the present connexion.

In a later report (Rhodin and Dalhamn, 1956) a detailed description will be given of the ciliary ultra-structure. The following paragraph contains a brief summary.

In its free portion a cilium consists of nine peripheral pairs of filaments, each pair with a common partition (Figs. 2 and 3). In the centre of the cilium are two distinctly separate filaments. The filaments are surrounded by a membrane 60

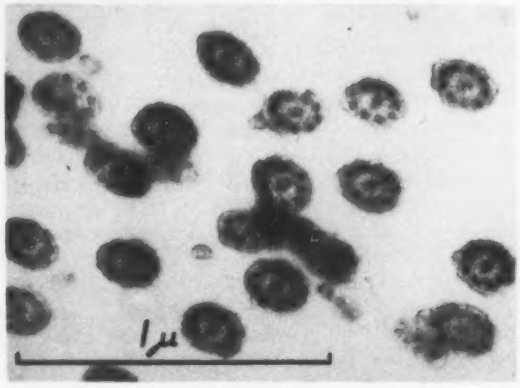
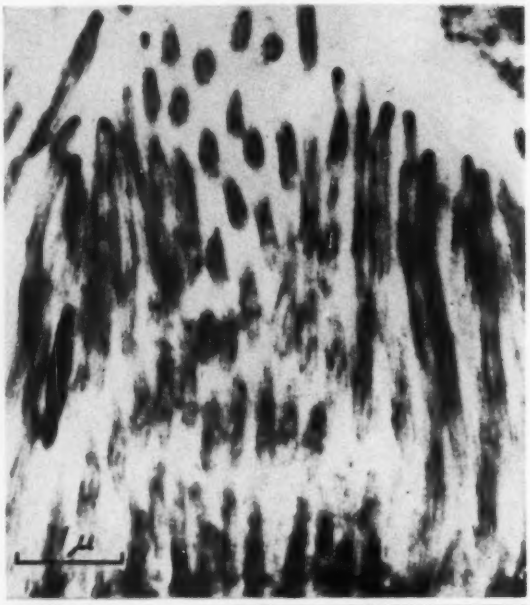


FIG. 2 (top, left).—Longitudinal section of cilia from the normal trachea of rat. × 15,750.

FIG. 3 (below, left).—Cross section of cilia from the normal trachea of rat. × 42,750.



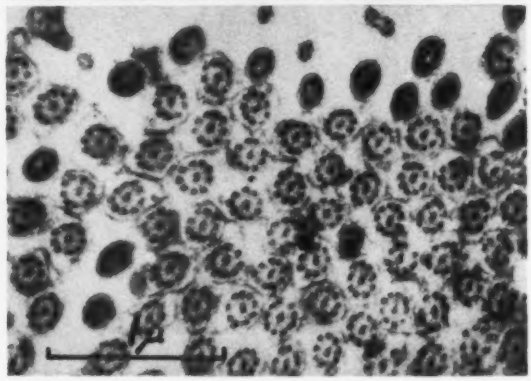


FIG. 4 (top, right).—Longitudinal section of closely packed cilia after exposure to SO_2 for 10 weeks. × 13,250.

FIG. 5 (below, right).—Cross section of cilia after exposure to SO_2 for 10 weeks. Note the abundant dense bacteria. × 24,000.

Ångström units in thickness and thus appear as tubular structures. In longitudinal sections the peripheral filaments are seen to extend beyond the surface of the cell and down into the basal corpuscle, in which they are tightly packed around a weakly osmiophilic substance, in the centre of which can be observed a strongly osmiophilic body. The two central filaments, on the other hand, do not reach down into the basal corpuscle, but appear to terminate roughly on a level with the cell surface. In cross sections from the region of the basal corpuscles all the peripheral paired filaments are clearly visible in a garland-shaped arrangement. At the lower tip of the corpuscle may be observed a number of fine rootlet fibres which can be followed only for a short distance inwards towards the interior of the cell. Immediately below the basal corpuscle is an accumulation of oval or spherical mitochondria separated from the cytoplasm by a double membrane; they also have an internal system of such membranes which, in contrast to earlier described types, are clearly branched.

Ultra-structural study of tracheal cilia in the rats exposed to SO_2 revealed no evidence of changes in the free portion of the cilia, in the basal corpuscles, or in the mitochondria (Figs. 4 and 5). The increased density of the cilia noted at microscopy, on the other hand, was clearly discernible, and in all

probability was caused by a reduction of the free surface of the ciliated cells.

Results and Conclusions

The apparatus employed permits meticulous determination of the rates of mucous flow and ciliary beat. With this method the action of certain pulmonary irritant gases has been studied. For the prolonged exposure herein discussed, SO_2 was chosen. It has earlier been demonstrated (Amdur, Melvin, and Drinker, 1953) that even low concentrations of this gas may give rise to several changes in the respiratory pattern.

The results of the present experiments show that functional and morphological changes occurred after 10 weeks' exposure to 10 p.p.m. (10^{-3} volumes %) SO_2. Thus the rate of mucous flow was considerably reduced and the amount of secretion greatly increased. The rate of ciliary beat, on the other hand, was unaffected. Nor did the phases of the ciliary beat appear to alter in character.

The morphological reactions were mainly seen in the epithelium and lamina propria. The epithelial cells were long and slender with compressed nuclei. The surface facing into the tracheal lumen was very irregular and showed deep crypts.

In the lamina propria there was severe oedema with splitting and fragmentation of the collagen fibrils, profuse vascularization, and blood escaping perivascularly.

The electron microscopic studies reported here particularly concerned ciliary structure. This did not differ from the structure observed in healthy rats.

It would thus seem that the functional changes noted are primarily attributable to alterations in the character of the mucosal secretion and not to injury to the ciliary mechanism as such. The results of the morphological studies confirmed these findings.

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TWO CASES OF META-DINITROBENZENE POISONING WITH UNEQUAL CLINICAL RESPONSE

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The toxicity of *m*-dinitrobenzene has been known for about 85 years (Starkow, 1871). The first clinical cases of poisoning to be reported in the literature were in workers engaged in the production or handling of the explosive roburite (Nieden, 1888 ; Ross, 1889 ; Prosser White, 1889 ; Röhl, 1890 ; Spurgin, 1891), or that of aniline (Schröder and Strassmann, 1891), or were due to other occupational hazards (Huber, 1891). Numerous cases of industrial poisoning have been reported since then (von Oettingen, 1941). They were also mostly due to exposure in the manufacture of explosives, especially in the first world war. Cases of poisoning among munition workers were again recorded during and after the second world war (Rejsek, 1944 ; Glahn and Schack-Schou, 1947). Owing to modern improvements in hygienic conditions, however, cases of poisoning in industry seem now to be seldom encountered.

Considered retrospectively, the characteristic clinical manifestations of *m*-dinitrobenzene poisoning were already well recognized by the early authors. The most comprehensive clinical descriptions and a review of the first reports were given by Koelsch (1917). Since these early descriptions little has been added to the symptomatology of intoxication by the subsequent clinical reports. Recent experimental investigations on *m*-dinitrobenzene poisoning in Germany (Kunz, 1942 ; Kiese, 1949 ; Kiese and Siems, 1949 ; Cammerer, Kiese, and Tauschwitz, 1949 ; Gaede and Kiese, 1949) are also in agreement with the clinical observations. Thus both from the study of cases of *m*-dinitrobenzene poisoning in human beings and from experimental work on animals the most toxic effects may be summarized as follows : (1) effects on the blood, (2) effects on the liver, and (3) effects on the central nervous system.

It is well known that the toxic effects of aromatic nitro compounds vary with the intensity and length of the exposure and, according to Koelsch (1954), with the individual susceptibility in particular. Regarding the toxicity of *m*-dinitrobenzene, Monks as early as 1902 points out that " there seems to be in some people a well marked idiosyncrasy to the poison, for all workmen are by no means equally affected ". A similar statement has also been made by Steiner (1918).

This paper gives an account of two patients who developed a somewhat different clinical picture of *m*-dinitrobenzene poisoning although working under exactly identical conditions and apparently exposed to the same extent to the toxic action of the poison.

Process and Hazards

The two patients were female process workers employed by a chemical firm and engaged in the manufacture of dinitrobenzene which was occasional and on a small scale. *m*-Dinitrobenzene was obtained by the classical method, *i.e.*, by nitration of mononitrobenzene using the so-called nitration mixture (sulphuric and nitric acids). In this process the crude nitration product is washed several times with hot water. After being sufficiently freed from acids the technical product is submitted to recrystallization by dissolving it in boiling 96% ethyl alcohol and refluxing. After the addition of active charcoal for decoloration the mixture is filtered through canvas into a container. After separation of crystals the alcohol is removed by filtration through a Büchner funnel.

Occupational hazards which may arise during the synthesis of *m*-dinitrobenzene are : (1) handling the technical product before and after recrystallization (weighing, emptying the funnel), and (2) exposure to *m*-dinitrobenzene vapours during the filtration through the canvas filter. Since, however, *m*-dinitrobenzene boils at 297° C. the actual hazard of vapours at the temperature of filtration does not seem to be probable.

The workers were provided with protective gloves which, however, they did not wear at all, although warned against the danger of handling the substance with bare hands. The processes of nitrating mononitrobenzene and of washing and drying the technical product were carried out under an exhaust hood, while the filtration of the alcoholic solution of *m*-dinitrobenzene was performed in the open.

The nature of the work makes it difficult accurately to define the degree of exposure for each individual affected. There is no evidence, however, that one of them was more exposed to *m*-dinitrobenzene than the other: the length and the periods of exposure as well as the kind of work performed were equal.

Case Histories

Case 1.—A woman, aged 22, was admitted to the Institute's Department for Occupational Diseases on October 28, 1954, complaining of severe headache, abdominal pain, and nausea. There was a two-day history of loss of appetite, headaches, weakness, and sweating. In spite of these symptoms she continued to work, having been engaged in the preparation of dinitrobenzene since October 20. On the day of admission, while at the ordinary course of her work, she developed abdominal pain accompanied by nausea and dizziness. A friend drew her attention to the appearance of her lips which became "black-blue". She reported to the ambulance room where the administration of oxygen was started but was soon discontinued because she became increasingly dyspnoeic and dizzy, and she was transferred to the hospital by ambulance.

On examination she was found to be of a normal physique but pale with a marked cyanosis of the lips, oral mucosa, conjunctivae, ears, and finger tips. The skin of the palms and palmar aspect of the fingers was thick and yellow-brown. The colour of her finger nails was reddish-brown. The pulse rate was 98 per minute, and temperature 37·4° C. The blood pressure was 105/55 mm. Hg. The respiratory rate was slightly raised and the patient complained of air hunger. There was abdominal tenderness, especially marked along the right costal margin. The liver was palpable and very tender. No abnormality was detected in the nervous system.

Laboratory Investigations.—The erythrocyte sedimentation rate was 20 mm. in one hour and 35 mm. in two hours (Westergren). Haemoglobin was 63% (Sahli). A blood count gave 3·54 millions per c.mm. red cells and 6,700 per c.mm. white cells with a normal differential count. Reticulocytes were 1·8% and Heinz bodies were not present. An osmotic fragility test was normal. The serum bilirubin was slightly raised to 1·66 mg. per 100 ml. (normal range up to 1 mg. per 100 ml.), the indirect van den Bergh test gave 0·73 mg. per 100 ml., thymol turbidity 4 units, and alkaline phosphatase 3·6 Bodansky units. The blood urea, serum iron, and fasting blood sugar levels were within normal limits. The concentration of methaemoglobin determined spectrophotometrically by the method of Heilmeyer (1943) was found to be 28% of total haemoglobin. No other pathological blood pigment could be detected spectroscopically. Routine examination of the urine for albumin, sugar, urobilinogen bilirubin, and blood revealed no abnormality. The excretion of ether-soluble porphyrins in the urine was 75 μg per 24 hours.

Progress.—Ascorbic acid (1 g.) was given intravenously on admission after a blood sample for estimation of methaemoglobin had been taken. She continued to experience nausea for two hours and complained of epigastric pain. Later in the evening she was still cyanosed and was again given ascorbic acid (1 g.) intravenously. Throughout the second day she was only slightly cyanotic and her condition much improved. Nevertheless, the liver was found to be even more enlarged, two finger-breadths below the costal margin. The temperature was 37·4 to 37·7° C. and the blood pressure 110/70. For the next eight days the liver was still enlarged and tender. She was on a high-carbohydrate, high-protein, and low-fat diet. During her stay in hospital the liver function tests were again performed but revealed no abnormality. The subsequent serial red blood cell and reticulocyte counts together with haemoglobin and methaemoglobin determinations are shown in Fig. 1. Heinz bodies were absent throughout.

She was discharged from hospital on November 12 as an out-patient. When seen on November 30 she was clinically well. The liver was neither palpable nor tender. The blood picture and the liver function tests were normal.

Case 2.—A woman, aged 25, was admitted to the same Department two hours after the admission of her fellow worker, Case 1, because the suspicion of a similar poisoning had been aroused. She was engaged in the same work preparing *m*-dinitrobenzene. Three days before admission she felt sick, with general weakness, loss of appetite, ease of fatigue, and "nervousness". She did not give up her work, however, hoping that she would soon be better. During these three days she had also noticed that her lips were blue but the colour was never so deep as that in Case 1 on the day of the latter's admission. She had no abdominal pain, no nausea, no temperature, no headaches.

On admission she felt very weak and dizzy; she was found to be of a rather poor physique, pale but only slightly cyanotic. The colour of the skin of the palms and fingers as well as of the finger-nails was yellow-brown. Her pulse rate was 76 per min., temperature 36·4° C., and blood pressure 120/65 mm. Hg. There was no abdominal tenderness and the liver was not palpable.

Laboratory Investigations.—The E.S.R. was 7 mm. in one hour, Hb 60% (Sahli), R.B.C.s 3·26 millions per c.mm., W.B.C.s 5,500 per c.mm. with a normal differential count, reticulocytes 4·7%, and Heinz bodies 38%. The serum bilirubin level was 1·74 mg. per 100 ml. and the indirect van den Bergh test gave a result of 0·57 mg. per 100 ml. Other tests for liver function were normal. Serum iron was raised to 206 μg per 100 ml. (normal range for female 80–130 μg. per 100 ml.). The blood urea and fasting blood sugar levels were normal. Methaemoglobin was 16% of total haemoglobin, but no other pathological pigment was found. An osmotic fragility test was within the normal range. The urine showed no proteinuria or other abnormality. Urinary excretion of ether-soluble porphyrins in the 24-hour specimen was 84 μg.

Progress.—The patient was treated with 1 g. ascorbic acid daily. From the second day she was not cyanosed and complained only of the "nervousness" and fatigue. Because of a relatively high Heinz bodies count her red

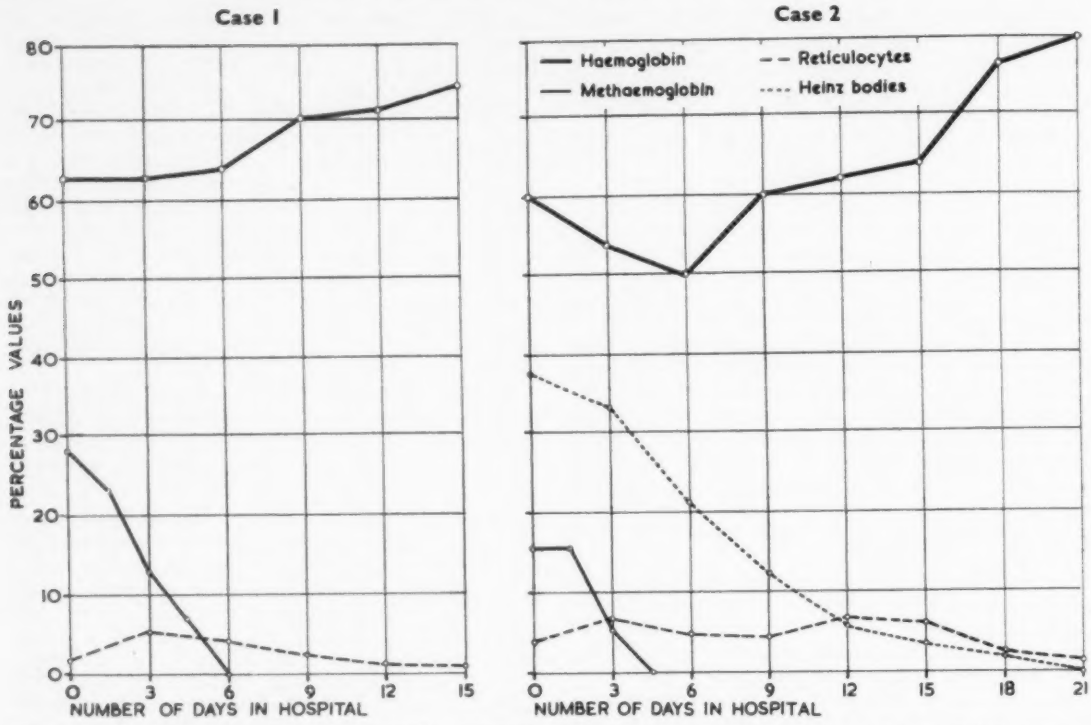

FIG. 1.—Graphs showing percentages of haemoglobin, methaemoglobin, reticulocytes, and Heinz bodies during the clinical course of intoxication.

blood picture was daily controlled: the course of the haematological investigations is shown in Fig. 1. Except for the haematological changes the patient showed no other clinical evidence of *m*-dinitrobenzene poisoning. On November 15 the serum iron was 87 μg. per 100 ml. She was discharged from hospital on November 19. When seen again she was clinically well. The only complaint was that of sleeplessness.

Discussion

The cases described here were women exposed to apparently identical risks of *m*-dinitrobenzene poisoning. After a week of exposure each developed symptoms and signs characteristic of the subacute type of *m*-dinitrobenzene poisoning, but there were certain differences in clinical features which should be particularly considered.

The most prominent effect of *m*-dinitrobenzene is its action on the blood pigment causing the formation of methaemoglobin. Accordingly methaemoglobinaemia is the commonest finding in most cases reported in the literature, although in a certain number of cases the authors failed to identify the pathological pigment (von Oettingen, 1941; Rejsek, 1944). Both cases recorded here suffered from methaemoglobinaemia; its level was higher in Case 1 and she also showed a higher degree of cyanosis.

The other product of the action of the poison upon the red cells is the formation of Heinz bodies in erythrocytes. Although much attention has been devoted to the blood changes in *m*-dinitrobenzene poisoning, many clinical observers made no mention of the incidence of Heinz bodies. Actually, as far as I can ascertain, only in four reports has the phenomenon of Heinz bodies been observed in connexion with clinical poisoning (Huber, 1891; Freifeld, Schilowa, and Ludwinowsky, 1937; Rejsek, 1944; Jung, 1946–47). In experimental poisoning, however, *m*-dinitrobenzene is shown to be a very good producer of Heinz bodies.

A relatively high number (38%) of Heinz bodies (Fig. 1) was the prominent finding in Case 2 described here, whereas not a single erythrocyte with Heinz bodies could be detected in Case 1. In view of the concept that there exists a direct relation between the formation of methaemoglobin and Heinz bodies (Schilling, 1932; Moeschlin, 1942), it is noteworthy that the level of methaemoglobinaemia was even higher in Case 1 which had no Heinz bodies at all. In one case mentioned by Jung

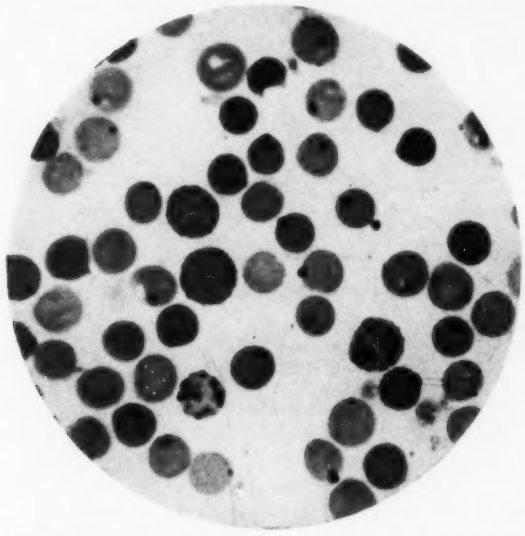

FIG. 2.—Heinz bodies and reticulocytes in Case 2 (brilliant cresyl blue supravital staining).

(1946–47) Heinz bodies appeared only after a second exposure to *m*-dinitrobenzene ; from the graph presented by Jung it may be seen that methaemoglobinaemia in his case was also higher after the first exposure when no Heinz bodies were found. Thus, the assumption that Heinz bodies and methaemoglobinaemia are closely associated does not hold true in all cases. These clinical observations support the view of Heubner (1943) that the occurrence of Heinz bodies and methaemoglobinaemia are separate and independent phenomena. *m*-Dinitrobenzene, a toxic substance which is known to be a good producer of both phenomena, produced in one person both methaemoglobin and Heinz bodies but failed, under presumably identical circumstances, to produce the latter phenomenon in the other person.

Regarding the diagnostic significance of Heinz bodies, it has been repeatedly suggested (Schilling, 1932 : instruction of the German Government, 1941, quoted by Hughes and Treon, 1954 ; Gross, Bock, and Hellrung, 1942) that their determination might as an alternative test replace the more complicated estimation of methaemoglobin. Although the two isolated cases presented here furnish inadequate material from which to draw any general conclusions, it may easily be seen that one should not rely solely on the presence or absence of Heinz bodies for evaluation of the degree of toxic action of *m*-dinitrobenzene. A similar observation has recently been made by Hughes and Treon (1954) : in three cases of poisoning due to " an aniline compound " they found both methaemoglobinaemia and Heinz bodies, while in the fourth " methaemoglobinaemia to the extent of 26·3% was found, but there were no Heinz bodies in the erythrocytes ".

A moderate degree of anaemia was present in both cases with a slight difference in initial values for haemoglobin concentration and red cell count. However, as shown in Fig. 1, a steady rise in haemoglobin took place in Case 1, while first a fall then a rise was noted in Case 2. As evidenced also by the simultaneous rise of reticulocytes and by the serum iron values, an increased red cell turnover was more pronounced in Case 2. A rise in serum iron has also been observed in experimental intoxication in animals (Cammerer and others, 1949).

In the first case described here the liver was tender and enlarged ; the transient gastro-intestinal symptoms, including nausea and epigastric pain, might also be attributable to the lesion of the liver. It must be noted, however, that although the liver became progressively enlarged, the only abnormality, as shown by the liver function tests, was a slight and transient rise in serum bilirubin. Except for a similar slight increase of bilirubin in the blood of the second case there were neither clinical nor laboratory data which indicated liver damage.

Summarizing the main clinical features of the above cases, it is found that there was in Case 1 toxic methaemoglobinaemia with a moderate anaemia but without Heinz bodies in the erythrocytes ; enlargement of the liver with gastro-intestinal symptoms was in this case indicative of a liver injury. There was anaemia with Heinz bodies and no evidence of liver damage in Case 2. The unequal incidence of toxic symptoms under conditions of equal exposure in these cases points to the individual differences in response to the toxic action of *m*-dinitrobenzene.

Summary

Two cases of industrial *m*-dinitrobenzene poisoning in women are reported. The patients were engaged in the manufacture of *m*-dinitrobenzene ; the process and the potential hazards of the work are briefly described. The differences in clinical features, particularly in regard to the occurrence of Heinz bodies, methaemoglobinaemia, and liver damage are stressed and discussed.

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A SOCIAL AND OCCUPATIONAL STUDY OF INJURED HANDS

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Most of us depend on our hands for our livelihood. Even today when the skilled hand of the craftsman has largely been replaced by the simpler movements of the machine minder, very little can be done in industry without the skilled use of the worker's hands, and the effects of an injury to the hand are probably no less than the effects of damage to the eye or to the head.

The objects of this study were : (1) to find out the causes of hand injuries amongst a group of men working in the north east of England ; (2) to record the opinions of these men about why their injury happened ; (3) to discuss prevention ; (4) to enquire into the cost of these hand injuries, measured in terms of money and time lost by the men ; and (5) to make an intensive study of a group of more severely injured men to find out the effect of the injury on their social and working lives, and to make some kind of assessment of residual disability.

It must be emphasized that the approach was not a medical one and that only the social, economic, and occupational aspects were considered. Problems of surgical technique and treatment are outside the scope of this study, although it is true that the social and medical aspects cannot be completely separated and that some overlapping of interests is inevitable.

The research included infections as well as injuries of the hand, but since the two conditions present rather different problems, they have been dealt with separately. The results of the work on infected hands have been published elsewhere (Wilkes, 1954), and they will not be considered in this paper. It may be of some interest, however, to mention that the men with infected hands were usually away from work for two to four weeks, and that 45 men (30%) had no known history of injury. Injuries which gave rise to infection were trivial ones, and were usually caused by knocking the hand against something rough or sharp. There was no evidence of any unreasonable neglect of the injury.

The method of study was described in detail in the paper dealing with hand infections, and it need only be said here that, for the most part, the data are based on information given by the men during one or more interviews. The men were all attending the hand clinic of the department of surgery in the Royal Victoria Infirmary, Newcastle upon Tyne.

The Men Interviewed

Two hundred and ninety-seven men were interviewed during the period March to December, 1952. Forty per cent. (119) were miners, and the other large occupational groups were engineers (70), woodworkers (30), and workers in unskilled occupations (23). The remaining occupational groups were made up of workers in the building trade (8), transport workers (6), slingers and crane drivers, and a small number of professional workers, agricultural workers, unemployed men, and men in other occupations. Nearly all the men came from industries in and around Newcastle and from pits in Northumberland and Durham, and they attended the clinic immediately after the injury. The ages of the men ranged from 15 to 65 years, but 86·5% (257) were under 55. There were 41 men (13·8%) under the age of 20. There were no women or children.

The Diagnoses

The diagnosis of a hand injury is complicated because there is often more than one feature. Table 1 shows that in the present series approximately one half of the men had more than one kind of injury. Nearly half the injuries (141) involved a laceration, 77 injuries involved a joint or bone, and 62 involved a loss of skin sufficient to need a graft. Traumatic amputations (50), tendon injuries (49), and crush injuries (45) were also common. The

TABLE 1
CLASSIFICATION OF INJURIES

Medical Diagnosis	Occupation											
	Mining		Engineering		Wood-working		Unskilled		Other		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Laceration only	31	26·1	15	21·4	1	3·3	4	17·4	9	16·4	60	20·2
,, and joint or bone injury	13	10·9	7	10·0	3	10·0	3	13·0	3	5·5	29	9·8
,, and tendon injury	3	2·5	5	7·1	3	10·0	—	—	3	5·5	14	4·7
,, and crush injury	4	3·4	2	2·9	1	3·3	—	—	—	—	7	2·4
,, and skin loss	1	0·8	1	1·4	2	6·7	—	—	2	3·6	6	2·0
,, and traumatic amputation	1	0·8	2	2·9	—	—	—	—	—	—	3	1·0
,, and nerve injury	1	0·8	—	—	—	—	—	—	—	—	1	0·3
Skin loss only	8	6·7	10	14·3	7	23·3	1	4·3	5	9·1	31	10·4
,, ,, and traumatic amputation	5	4·2	1	1·4	—	—	—	—	1	1·8	7	2·4
,, ,, and crush injury	2	1·7	—	—	3	10·0	1	4·3	1	1·8	7	2·4
,, ,, and joint or bone injury	3	2·5	2	2·9	—	—	—	—	1	1·8	6	2·0
Tendon injury only	1	0·8	1	1·4	1	3·3	2	8·7	1	1·8	6	2·0
,, ,, and joint or bone injury	5	4·2	1	1·4	—	—	1	4·3	2	3·6	9	3·0
,, ,, and traumatic amputation	—	—	1	1·4	—	—	—	—	1	1·8	2	0·7
,, ,, and crush injury	1	0·8	—	—	—	—	—	—	—	—	1	0·3
Joint or bone injury only	2	1·7	1	1·4	—	—	3	13·0	1	1·8	7	2·4
,, ,, ,, ,, and crush injury	—	—	—	—	—	—	2	8·7	2	3·6	4	1·3
,, ,, ,, ,, and traumatic amputation	1	0·8	—	—	1	3·3	—	—	1	1·8	3	1·0
Traumatic amputation only	13	10·9	9	12·9	2	6·7	1	4·3	5	9·1	30	10·1
,, ,, and crush injury	1	0·8	—	—	—	—	—	—	—	—	1	0·3
Nerve injury and tendon injury	1	0·8	1	1·4	1	3·3	—	—	—	—	3	1·0
Crush injury only	10	8·4	4	5·7	—	—	1	4·3	3	5·5	18	6·1
Burn only	—	—	1	1·4	—	—	1	4·3	4	7·3	6	2·0
Multiple injuries*	11	9·2	3	4·3	4	13·3	2	8·7	5	9·1	25	8·4
Miscellaneous	1	0·8	3	4·3	1	3·3	1	4·3	5	9·1	11	3·7
Total	119	99·6	70	99·9	30	99·8	23	99·6	55	100·0	297	99·9

* " Multiple injuries " means more than two kinds of injury.

injuries were severe enough to keep the man off work, and all the men were admitted to the hostel attached to the hand clinic where the usual length of stay was one week. Some of the more severe injuries were excluded because when extensive grafting is required immediately, the injured man goes straight to the plastic unit and is not seen in the hand clinic at all.

Anatomical Site

Table 2 shows the parts of the hand involved in the injuries. It is interesting to note that there were almost as many injuries to the left hand as to the right, and the woodworkers actually had more left-hand injuries. Finger injuries were by far the most common. Two hundred and twenty-three of the injuries (75·1%) occurred to one or more fingers only, and 37 of the injuries (12·5%) were to the thumb only. The remainder were to the palm or the dorsum or the wrist only, or to the thumb and one finger or to some other combination of the parts of the hand.

The Cause of the Injury

Statements made by the injured person do not give the whole story of how and why an accident happened, but it was thought that something could be

TABLE 2
SITE OF THE INJURY

Occupation	Thumb	Thumb and Finger(s)	Finger(s) Only	Palm	Dorsum	Other	Total
Right hand							
Mining	6	—	54	2	1	4	67
Engineering	2	—	30	—	2	2	36
Woodworking	4	1	9	—	—	—	14
Unskilled	3	—	6	1	—	—	10
Transport	—	—	1	1	—	—	2
Building and contracting	—	1	4	1	—	—	6
Others	1	1*	16	—	1	—	19
Total	16	3	120	5	4	6	154
Left hand							
Mining	6	1	37	3	4	1	52
Engineering	5	1	26	—	1	1	34
Woodworking	1	2	13	—	—	—	16
Unskilled	2	—	9	2†	—	—	13
Transport	—	—	4	—	—	—	4
Building and contracting	1	—	1	—	—	—	2
Others	6	1	13	—	1	1	22
Total	21	5	103	5	6	3	143
Grand total	37	8	223	10	10	9	297
Percentage	12·5	2·7	75·1	3·4	3·4	3·0	100·1

* Also injured left hand slightly. † Also injured right hand slightly.

TABLE 3
THE CAUSE OF THE INJURY (AT WORK ONLY)

Cause of the Injury	Occupation															
	Mining		Engineering		Wood-working		Unskilled		Transport		Building and Contracting		Other		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Machinery	13	11·1	35	53·8	25	83·3	6	27·3	1	16·7	1	12·5	13	41·9	94	33·7
Handling goods ..	12	10·3	13	20·0	1	3·3	10	45·5	2	33·3	1	12·5	11	35·5	50	17·9
Struck by falling body	39	33·3	5	7·7	—	—	1	4·5	—	—	1	12·5	1	3·2	47	16·8
Moving objects ..	32	27·3	—	—	—	—	2	9·1	1	16·7	1	12·5	—	—	36	12·9
Use of hand tools ..	2	1·7	5	7·7	2	6·7	—	—	1	16·7	2	25·0	3	9·7	15	5·4
Struck by rising body	11	9·4	1	1·5	—	—	1	4·5	—	—	—	—	—	—	13	4·7
Persons falling ..	6	5·1	3	4·6	1	3·3	—	—	—	—	1	12·5	1	3·2	12	4·3
Striking against objects	—	—	—	—	1	3·3	—	—	1	16·7	—	—	—	—	2	0·7
Other	2	1·7	3	4·6	—	—	2	9·1	—	—	1	12·5	2	6·5	10	3·6
Total	117	99·9	65	99·9	30	99·9	22	100·0	6	100·1	8	100·0	31	100·0	279	100·0

learned by asking the patient to give details of his accident and to say what he thought had caused it. It is seldom easy to know exactly why an accident happened, especially for those who are involved in it, and the value of this part of the study largely depends on the honesty and intelligence of the men who were questioned.

Two hundred and seventy-nine of the injuries occurred at work and 18 injuries were the result of accidents at home, on the road, or elsewhere.

Table 3 sets out the causes of the injuries occurring at work. A little over a third (33·7%) of the injuries were caused by machinery. This emphasizes the severity of the injuries and is in accordance with the findings of Rank and Wakefield (1953) who noted that among 1,000 cases of hand injuries which involved hospital admission a high proportion were due to machinery. It is perhaps surprising that in the present series a higher proportion was not caused by machinery, but it should be remembered that 40% of the men were miners, and in spite of the increasing mechanization of the pits comparatively few mining accidents are caused by machinery. If the miners are omitted the proportion of accidents caused by machinery rises to a half.

Two-thirds of the machinery accidents happened to workers in the engineering and woodworking trades. This is not surprising since workers in these occupations are particularly exposed to this risk. Eighteen of the men (19%) involved in machinery accidents mentioned speed of working as a chief cause of the accident.

Case 1.—A 16-year-old wood machinist amputated the right index and middle fingers when he picked up a block of wood from the table of a rotating circular saw. It is the practice in his firm to remove blocks of wood by hand after they are cut, and since the blocks are touching the saw it is clearly a dangerous practice even when the blocks are large. On this occasion the block was only two inches long and the boy's hand was easily caught on the saw. The boy knew that the correct method of removing blocks of any size is by using a push stick, but he said that nobody bothers to do this as it is quicker and less trouble to use the hand. He only did what he had seen the men doing.

Twelve men blamed their machines for their accident, and amongst these were three who said their machines had no guard, and one man who worked a planing machine and described the guard as " laughable ".

Case 2.—A bakery worker was cleaning dough out of a divider when the clutch slipped, and the blade moved forward cutting off all the fingers of his right hand. He said that the divider was an old machine and it had not been properly maintained. The only safe way to clean the divider was by turning off the electricity, but this was never done because there was only one switch for the whole plant, and the divider could not be stopped without stopping other machines on the same circuit. After the accident the divider was built up on three sides so that no one could get a hand in, and an automatic safety device was put on the cutter. The method of cleaning the dough cutter was also altered, and the divider cannot now be cleaned unless the electricity is cut off at the source by the foreman, and the machine dismantled. This method takes half an hour whereas the previous method of using the clutch as a brake, standing on the conveyor belt supports, and putting a hand in at the top of the hopper took two minutes.

In two instances the design rather than the maintenance of the machine seems to have been at fault.

Case 3.—A lathe was being worked by a boy of 15 years and because of his smallness he had to lean over the machine to tighten the key in the chuck. As he did so his thigh touched the starter and set the machine off. The middle finger of his right hand was lacerated when the key came round and jammed the hand against the bed of the machine. The boy thought it would have been better if the starter had either been shrouded or had not been the kind that starts at a touch.

Woodworking machinery accidents were sometimes attributed to faults in the wood, as for example a knot causing the wood to jump. Some men were critical of the foreign timber now being used in some factories. This wood was said to be badly cut and seasoned, and it was kiln dried, which one man said " takes the nature out of the wood ".

Twelve of the machinery accidents were attributed, at least in part, to inexperience or lack of proper instruction. These reasons naturally apply particularly to young people, but adults too became involved in accidents when they were using machines they did not normally use or doing work to which they were not accustomed.

Case 4.—One of the mining accidents occurred when a datal (day rate) worker, who was normally employed as a bricklayer's labourer in the pit, was helping with some of the general labouring work because there was no bricklaying work to be done that day. The accident happened when he was putting some cable on to a conveyor belt and someone set the belt away unexpectedly, jamming his fingers against the box end. If work on the conveyor belt had been his regular job he would have been more efficient with his signals. He added that they were not supposed to put cable on the conveyor belts but he had been told to do it.

Case 5.—Lack of supervision was blamed for an accident occurring to a 15-year-old apprentice fitter. He was cleaning a screwing machine when a bolt came round on the chuck and jammed his left thumb. He had worked the machine for one month and had originally been shown how to work it by another apprentice fitter, aged 16 years. After the first two days he was left in sole charge, and he thought his accident would not have happened if there had been someone to remind him of the dangers of his machine. His accident happened at the start of the day, and he was glancing up at the clock when he felt his hand being drawn into the machine.

A misunderstanding was a cause of some machinery accidents, as in the example quoted above when the conveyor belt was set away unexpectedly. Some accidents, especially on grindstones, were undoubtedly caused when the man relaxed his grip, perhaps because he was tired or his hands were cold. The danger of wearing loose clothing near moving machinery was illustrated by two accidents where clothing became involved in conveyor belt rollers and one accident where a man's safety glove was caught in a flanging machine.

Fifty accidents (17·9%) occurred to men when they were using their hands to move objects from one place to another or on and off machines. In this paper, accidents involving lifting machinery, whether moved by power or not, are included in the " handling goods " category provided that the man was injured while his hands were in contact with the load. Fourteen accidents (28·0%) in this group involved the use of cranes and occurred to slingers. These accidents often occurred when the load toppled over in the sling as the slinger was guiding, loading, or unloading the sling. Misunderstanding between slinger and crane driver caused six accidents, and the misunderstanding arose either because the wrong signal was given or because the crane driver was not looking, or was unable to see because of the position of his box. Other " handling goods " accidents happened when the object being handled was slippery or difficult to grip, and a number of objects toppled over at a touch for no reason at all that the man could think of. In general, crane accidents excepted, accidents caused by handling were considered to be unavoidable. To the injured man his accident was just " one of those unforeseen things ".

Of 117 accidents to miners, 39 (33·3%) were caused by something falling. Often (26 accidents) the object falling was a piece of stone and this usually came from the roof, although in three instances the man was injured by a stone thrown by his mate. Other injuries to miners were caused by girders or props falling over and these accidents usually happened when men lost their balance while putting up props, or were in too much of a hurry to do the job correctly. Falls of stone are difficult to prevent but two miners remarked that these accidents are often caused by good stone rather than bad, the implication being that more risks are taken with good stone, whereas men usually watch bad stone and take care to see that the roof is propped as it should be.

Over a quarter of the mining accidents were caused by tubs or trams running over or crushing the hand. These accidents happened to men when they were pushing tubs or trams (15 accidents), coupling or uncoupling tubs (seven accidents), clipping or unclipping sets (seven accidents), or braking tubs with drags (three accidents). Often (14 accidents) the man's hand was caught between two tubs. Five of the accidents involved ponies, and three of these were said to have happened because the man involved was not used to ponies and did not understand the pony he was dealing with. Other men said that they had been rather slow in getting out of the way of the tubs or that they had put their hands in the wrong place, although there seems to be no safe place for hands to be put when handling tubs since hands were hit when they were at the back, on the top, and at the side of tubs. The most frequent complaint was that there was not enough room between the tubs when they were standing buffer to buffer.

Other injuries were caused by hand tools or by falls, and in the pits 11 injuries were caused by girders or tubs rising and crushing the man's hand against the roof. These " rising bodies " accidents happened when a tub hit some obstruction or a joint in the rail and the back of the tub jumped up, or when one end of a girder or prop went down and the other end went up and hit the roof. Eight of the 15 injuries caused by hand tools were attributed to hammers, and five were caused by knives slipping. The falls were all on the flat and were caused by tripping or slipping either because the floor had not been kept clear or because there was oil or ice on the ground.

Case 6.—One of the worst injuries occurred to a miner who had gone down the pit carrying a glass medicine bottle full of oil for his pneumatic pick. He tripped over a stone and the bottle smashed in his hand as he hit the ground. His hand was badly cut across the palm and the residual disability was severe.

It was not possible to classify all the contributory factors mentioned, and a number of patients had no idea at all why their accident had happened. They could only say they had been careless and had put their hands in the wrong place. Often accidents were described as " a chance in a thousand " and not likely to happen again.

There were 18 injuries resulting from non-industrial accidents, eight of which were accidents in the home, two on the road, two on the playing fields, and six others.

Prevention

The above analysis of the causes of hand injuries indicates ways in which these accidents might be prevented. Some of the machinery accidents would not have happened if the machines had been well designed and well guarded, and some woodworking machinery accidents might have been prevented by the use of good, well-seasoned wood. In general many accidents of all kinds would be prevented if men and managements cooperated to ensure that the speed of working allowed men enough time to make the best use of all safeguards. Piece rates and bonus systems of payment were blamed for accidents more often than anything else because the men said that they were in too much of a hurry to be careful ; but it should be said that the blame for this does not belong entirely to managements since the men themselves often prefer to take risks rather than have their earnings reduced. Lack of adequate supervision seemed to be the cause of some accidents, and there were several instances of young people who had received no instruction or supervision after their first day or first time on the machine.

In the pits hand accidents usually occurred on haulage work or when stone fell from the roof. Falls of stone seem to be unpreventable unless they occur when the roof has not been propped correctly, and even then some stones become dislodged. Several miners suggested that many haulage accidents would be prevented if another inch or two were added to the buffers on tubs and trams, although this would add considerably to the total length of sets of tubs and might be impracticable on that account. The present length of tub buffers is about two and a half to three inches, giving a clearance space of five to six inches when two tubs are buffered together. Some of the miners said this was not a large enough clearance for a man's hand. Whitfield (1946) has pointed out that there would be more space between tubs when they were being coupled and uncoupled if this was done on a curve and not on a straight road, because on a curve only the inside buffers come into contact, leaving a safe working space on the outside for uncoupling. But it is not always possible to curve the track, and it might be as effective to couple tubs in the normal way, *i.e.*, with one hand on top of the tub and the other hand coupling the tub from underneath the buffers, but with longer buffers so that there is more room to manoeuvre between tubs.

Many accidents were due to personal factors, *e.g.*, misunderstanding, misjudgment, and lack of attention or thought. It is easy to be wise about these accidents after they have happened but it is difficult to know how to prevent them.

The Cost of the Injury

An attempt has been made to assess the personal hardship and loss to individual men in the follow-up study, and information concerning the financial cost and the time lost from work was obtained from nearly all the men.

Financial Cost.—Table 4 gives an idea of the amount of money lost each week while the man was off work, but it does not give the whole picture. Many of the men eventually made up what they had lost if they received income tax relief, disablement benefit, or awards for damages. On the whole those with any residual disability tended to gain financially from their injury since they were not off work long enough for the accumulated weekly loss to exceed the amount paid to them in disablement benefit. But in these instances money gain was, of course, paid for by some permanent impairment of hand function or loss of a part of a hand.

The weekly loss for men while they were off work varied around a mid-point of £3 10s., but miners and engineers often suffered income losses of over

TABLE 4
DIFFERENCE BETWEEN USUAL EARNINGS AND INCOME DURING ILLNESS

Weekly Loss	Occupation															
	Mining		Engineering		Wood-working		Unskilled		Transport		Building and Contracting		Other		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
No change	2	1·7	3	4·3	2	6·7	1	4·3	1	16·7	—	—	10	24·4	19	6·4
Less than £1	8	6·7	12	17·1	1	3·3	1	4·3	—	—	—	—	3	7·3	25	8·4
£1–£1 19s. 0d. ..	13	10·9	4	5·7	3	10·0	2	8·7	1	16·7	1	12·5	3	7·3	27	9·1
£2–£2 19s. 0d. ..	14	11·8	9	12·9	5	16·7	7	30·4	1	16·7	4	50·0	5	12·2	45	15·2
£3–£3 19s. 0d. ..	15	12·6	7	10·0	8	26·7	2	8·7	—	—	2	25·0	—	—	34	11·4
£4–£4 19s. 0d. ..	9	7·6	12	17·1	5	16·7	7	30·4	1	16·7	1	12·5	12	29·3	47	15·8
£5–£5 19s. 0d. ..	17	14·3	9	12·9	1	3·3	2	8·7	—	—	—	—	1	2·4	30	10·1
£6–£6 19s. 0d. ..	14	11·8	8	11·4	2	6·7	1	4·3	1	16·7	—	—	3	7·3	29	9·8
£7–£7 19s. 0d. ..	8	6·7	—	—	—	—	—	—	1	16·7	—	—	1	2·4	10	3·4
£8 and over	19	16·0	6	8·6	1	3·3	—	—	—	—	—	—	2	4·9	28	9·4
Other	—	—	—	—	2	6·7	—	—	—	—	—	—	1	2·4	3	1·0
Total	119	100·1	70	100·0	30	100·1	23	99·8	6	100·2	8	100·0	41	99·9	297	100·0

£8 a week, and the largest drop in income was to a miner who lost about £14 a week. Seventeen men, said there would be no change in their financial circumstances for the first few weeks they were off work, and there were two old-age pensioners whose income was unaffected. Two men actually gained a few shillings each week, and one man who was self-employed was unable to make any estimate of weekly gain or loss.

The employer, and ultimately the country, suffers too when a worker loses time through injury since the man has either to be replaced by another worker, in which case there is a man short in some other department, or he is not replaced and his mates either have to work harder, work overtime, or else production suffers. The self-employed are often hit the hardest since their work sometimes stops altogether and with it their income.

Time Lost from Work.—Information about the amount of time lost from work was supplied by all but 13 (4·4%) of the men, and this information is set out in Table 5. This Table shows that over three-fifths (65·3%) started work within eight weeks, and over four-fifths (82·1%) were back at work by the end of 12 weeks. Of the remaining 53 men, two were old-age pensioners who were not working and 13 provided no information. This leaves 38 men (12·7%) who were known to have been off work for more than 12 weeks, and 12 of these (4·0%) were off work for six months or more. Four men were off work for more than a year, and the longest period of incapacity was two years and eight months. The median duration for all the men was seven weeks. It is difficult to find comparable figures, but Barclay (1955a) in a study of 52 patients with finger tip injuries found that the average amount of time lost by patients who had had the finger amputated was 11·5 weeks, and when a free graft had been applied the average was nine weeks. The medians were 10 and eight weeks respectively (Barclay, 1955b). In the present series there were 90 men with finger tip injuries treated by amputation or free graft, and the median amount of time lost from work was six weeks for amputations and seven weeks for grafts. Barclay found that patients with finger tip amputations do not as a rule return to work for a comparatively long time and he suggested that it may take from two to three months for the stumps to harden enough for the injured person to undertake heavy work, and when machinery is involved it may take the same length of time for the man's confidence to be restored.

Some of the men in the present series were off work for a considerable time, but from the figures alone it is not possible to know whether or not there was any undue delay in returning to work.

Return to Work Related to Hand Clinic's Advice.—It is the policy of the Hand Clinic to discharge patients only when the hand has healed, and it is at this point that they are usually advised to start work, although some are given this advice during treatment. Table 6 shows that 54 men were advised to start work during treatment and that three men had already started work when this advice was given. One hundred and fifty-three men were discharged healed and fit for work. Of these 207 men, 85 (41%) started work during the week after discharge or the clinic's advice to them to start work. Three men started work a week or two before advice and the remaining 119 (57·5%) delayed for periods varying from two weeks to two months or more. The longest delay was 42 weeks. In addition, 12 men discharged themselves from the clinic and started work within a week of their last attendance. Twenty men presumably decided to attend their own doctors, since they did not come back to the clinic, but nevertheless they were off

TABLE 5
LENGTH OF TIME OFF WORK

Weeks off Work	Occupation															
	Mining		Engineering		Wood-working		Unskilled		Transport		Building and Contracting		Other		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1 2 3 4	— 1 5 8	11·8	— 3 5 9	24·3	— 2 1 4	23·3	1 2 2 2	30·4	1 1 — 1	50·0	2 — — 1	37·5	1 6 2 2	26·8	5 15 15 27	20·9
5 6 7 8	13 16 16 10	46·2	15 4 13 6	54·3	5 3 5 2	50·0	1 3 5 1	43·5	— — — —	—	2 2 — —	50·0	2 1 3 4	24·4	38 29 42 23	44·4
9–12	27	22·7	5	7·1	5	16·7	2	8·7	2	33·3	—	—	9	22·0	50	16·8
13–16	8	6·7	1	1·4	1	3·3	1	4·3	1	16·7	—	—	—	—	12	4·0
17–20	6	5·0	—	—	—	—	1	4·3	—	—	—	—	3	7·3	10	3·4
21–24	1	0·8	2	2·9	—	—	—	—	—	—	1	12·5	—	—	4	1·3
25 and over	6	5·0	3	4·3	—	—	1	4·3	—	—	—	—	2	4·9	12	4·0
Not known	2	1·7	4	5·7	2	6·7	1	4·3	—	—	—	—	4	9·8	13	4·4
Not applicable	—	—	—	—	—	—	—	—	—	—	—	—	2	4·9	2	0·7
Total	119	99·9	70	100·0	30	100·0	23	99·8	6	100·0	8	100·0	41	100·1	297	99·9

work for two weeks or more after their last attendance. Forty-one men returned to work before they were discharged from the clinic or before their last attendance. On the face of it it seems that these men returned to work before the clinic had advised them to do so, but it is possible that in some cases the men were advised to start work but no mention was made of it in the medical notes.

No special study was made to find out why there is sometimes a discrepancy between what the surgeon advised the man to do and what the man actually did, but the subject was raised with some of those who were interviewed on follow-up, and it is clear that there was more than one reason why men delayed returning to work. The following explanations were offered: (1) his own doctor advised him not to start work immediately; (2) he made his own decision not to start work immediately. He may have been afraid of knocking the hand when it was still tender, or having been off work for several weeks he was, perhaps, in no hurry to start again; (3) he was advised not to start work by a lay person, as for example a compensation secretary, although his general practitioner presumably must be partly responsible if he does not sign a final certificate; (4) the hand became worse and he either returned to the clinic or attended another hospital; (5) work of the right kind was not available. The difficulty is that there is no such thing as "work" but only the work the man did before he came to the hospital, and the work he can find when he leaves it. The term "light work" can be particularly unhelpful, and some men who had been advised by the clinic to start light work said they would have liked more discussion with the clinic surgeon on the kind of work he had in mind, and whether it was likely to be available; (6) his holiday period happened to come at the time when he would normally have started work.

TABLE 6
RETURN TO WORK RELATED TO ADVICE OF CLINIC
(TOTAL 280 PATIENTS)

No. of Weeks	Returned to Work				
	After Discharge from Clinic	After Advice to Start Work	Before Advice to Start Work	After Last Attendance at Clinic	Before Discharge from Clinic or Last Attendance
1	66	19	2	12	14
2	28	6	1	3	8
3	24	3	—	5	7
4	12	5	—	3	5
5	5	5	—	3	—
6	4	3	—	1	1
7	2	1	—	2	2
8	2	1	—	1	—
9 and over	10	8	—	2	4
Total	153	51	3	32	41

The Work the Men Returned to.—Table 7 shows that nearly three-quarters of the men went straight back to the jobs they were doing at the time of the injury. Sixty-five men (21·9%) were known to have changed their jobs when they started again, but 27 of these returned to their own work later. In five instances it was not clear whether the change was temporary or permanent. Thirty-three men (11·1%)

TABLE 7
RETURN TO WORK

Jobs Returned To	Occupation														Total	
	Mining		Engineering		Wood-working		Unskilled		Transport		Building and Contracting		Other			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Same job	87	73·1	56	80·0	19	63·3	18	78·3	4	66·7	6	75·0	27	65·9	217	73·1
Different job :																
Temporarily ..	17	14·3	3	4·3	3	10·0	—	—	—	—	—	—	4	9·7	27	9·1
*Permanently ..	8	6·7	7	10·0	6	20·0	4	17·4	2	33·3	2	25·0	4	9·7	33	11·1
Not known	5	4·2	—	—	—	—	—	—	—	—	—	—	—	—	5	1·7
Not known	2	1·7	4	5·7	2	6·7	1	4·3	—	—	—	—	4	9·7	13	4·4
Not applicable ..	—	—	—	—	—	—	—	—	—	—	—	—	2	4·9	2	0·7
Total	119	100·0	70	100·0	30	100·0	23	100·0	6	100·0	8	100·0	41	99·9	297	100·0

* Includes men who knew they would never return to their former employment and those who had not done so by the time of follow-up visit.

either knew that they would never return to their former employment or had not done so by the time of the follow-up visit one and a half to two and a half years after the injury. About three-quarters of those who had changed their jobs were visited in the follow-up study, and their reasons for changing will be discussed in the next section.

The Follow-up

The men who were visited in the follow-up study were selected because it seemed likely that there would be some residual disability, and they are therefore not representative of the whole group.

One hundred and fifty-seven men were selected for possible visits, but 57 of these visits were not made either because the men lived too far away (40), or they had changed their address (9), or were not in when called on (2), or because they had been called up or were ill or had died (6). The exclusion of those who lived far away from Newcastle meant that some of the more severely injured men were not visited, since those who came from a distance often came because their injuries were too serious to be treated at a local hospital where there was no hand clinic.

Over a third of the 100 men who were visited were miners (36), and the other main occupational groups were engineers (22), woodworkers (14), and unskilled workers (10).

It was originally planned to visit men about two years after the injury, and on the whole this was done. Eighty-nine men were visited one and a half to two and a half years after the injury, and 45 of these visits were made before the two years were up and 44 after. Eleven men were visited one year to one and a half years after the injury.

Residual Disability.—The men were asked if the injury troubled them in any way and the data are set out in Table 8. No tests were made of hand and finger function, but the statements of the men were supported by observation of the state of the hand, and, whenever possible, by noting the percentage assessment for disablement benefit made by the Ministry of Pensions and National Insurance.

TABLE 8
RESIDUAL DISABILITY AT TIME OF FOLLOW-UP VISIT

Residual Disability	No. of Men Total 100
No complaints	10
Appearance only	8
Involving pain or tenderness	62
Involving loss of grip	60
Involving limitation of movement	42
Involving numbness	29
Loss of grip associated with pain or tenderness ..	44

The injuries were all severe, and it is therefore satisfactory that 10 men could find nothing wrong with the hand. This group is comprised of six Thiersch grafts, and four sutures of extensor tendons. Seven of these men were under 33 years and the remaining three men were between 50 and 61. Of the 90 men who had some kind of residual disability, eight had a normally functioning hand but there was some obvious defect, for example, an amputation stump, a scar or slight discoloration, or a lumpy area of flesh where skin had been grafted. Sixty-two men complained of pain or tenderness, and 60 suffered some impairment of grip, and 44 of these men complained of loss of grip as well as pain or tenderness. Tenderness always referred to some sensitivity to touch especially at the finger tip or amputation stump, and those who complained of pain usually meant that the hand was painful in cold weather only. A few men complained of occasional attacks of cramp or aches in the hand, and one man said that his hand ached all the time and his doctor gave him sleeping pills because of this. Forty-two

men complained of limitation of movement caused by stiffness in the hand or fingers.

An attempt was made to relate disability to specific injuries or surgical treatments, but sometimes where the hand had received more than one kind of injury it was not possible to establish any direct relationship between these injuries and the resulting disabilities.

Out of a total of 51 men who had received skin grafts, 23 complained of soreness of the graft area and 12 men said there was no feeling in the graft. There were 31 Thiersch and 13 post-auricular grafts, and of these, 10 men (eight Thiersch and two post-auricular) had no complaints to make about the graft and nine others (seven Thiersch and two post-auricular grafts) had a perfect functional result but the graft area was clearly visible. Five men said that in the early stages the graft cracked easily or came up in pimples, and three men were troubled with the graft bleeding heavily when it was knocked. Seven men found the nail was a nuisance, either because there was not enough flesh underneath it or because it was not growing normally.

Twenty men had had amputations (15 surgical and five traumatic) not treated by grafting, and six of these were perfectly satisfied with the result. The remaining 14 men usually complained of numbness or stiffness, and one man was not at all pleased with the amputation stump which was red and bulbous, and he said he kept knocking it with painful results. Those who were left with stiff finger remnants said they would have preferred an amputation at the base of the finger, since the stump tended to get in the way.

Tendon injuries were responsible for several crippling disabilities. Of 24 men with tendon injuries (14 extensor, 10 flexor) five were left with normal function. In all these five cases the injuries had been to the extensor tendon and in each case the injury had been treated by primary repair. The usual disability was stiffness of the finger and in some cases there was no movement at all. Three men had the finger amputated later and one of these men went to another hospital for the amputation. The usual treatment of tendon injuries was primary repair, but no attempt was made to repair five of these injuries, and there was one graft. Four of the extensor tendon and two of the flexor tendon injuries were associated with bone injuries in the same finger, and this obscured the relationship between the disability and its cause.

There were four bone or joint injuries uncomplicated by any other kind of injury, and of these, one man had no complaint to make about the bone injury. The other three men complained of stiffness or pain, or a weakness of the hand causing some loss of grip.

Loss of grip was a characteristic of nearly all these disabilities.

Disablement Benefit

It is obvious that many of the men suffered very severe disabilities, and this is confirmed by Table 9

TABLE 9
DISABLEMENT BENEFIT AWARDED AT TIME OF FOLLOW-UP VISIT

	Assessment			
%	Final	Provisional	Did not Claim	Total
0	1	—	—	1
1–5	21	—	—	21
6–10	17	1	—	18
11–15	11	—	—	11
16–20	5	3	—	8
21–25	—	—	—	—
26–30	2	3	—	5
40	2	2	—	4
50	1	2	—	3
60	1	—	—	1
70	—	1	—	1
Did not claim	—	—	27	27
Total	61	12	27	100

which gives the disablement expressed as a percentage by the medical boards of the Ministry of Pensions and National Insurance. Twelve men were considered to have hand conditions which were liable to change appreciably with the passage of time, and they were therefore given provisional assessments to cover the period between one examination and the next. About two-thirds of those who claimed were assessed at between 1% and 15%, and the highest permanent assessment was 60% for a man who had lost all the fingers of his right hand. Twenty-seven men did not claim benefit, and this includes the 10 men who had nothing wrong with the hand, and two of these were not eligible for benefit since the injury had not occurred at work. This leaves 17 men who had some residual disability and who could have applied for benefit but did not do so. None of these men had gross hand disabilities, but had they applied they would probably have been assessed somewhere between 1% and 10%. A few of these men said they would apply for benefit after the follow-up visit, and two of them wrote later to say that they had been assessed at 5%. Usually when the men did not apply for benefit it was because they did not know about it, or because they thought they were not eligible. Some of the men considered their disability was too trifling to bother with. At the other extreme were those who were not satisfied with the assessment awarded to them. Five men had appealed against the medical board's decision, and three

others were considering an appeal. The five appeals were all successful.

The Psychological Effects of the Injury

The psychological effects of injury are important but they are hard to assess.

At the start of their incapacity some of the men were afraid of losing their jobs because of a crippling hand disability, but by the time of the follow-up visit most of them knew the extent of their disability and had accommodated themselves to it. Fear of injuring the hand again was mentioned by some men, and those who had sustained severe injuries as a result of a machinery accident were sometimes sickened by the accident so that they could not bring themselves to work the same machine again, even if they were physically capable of doing so.

There was no evidence to support the idea that a manual worker does not mind about the cosmetic result of treatment for a hand injury. Men of all ages and occupations were remarkably self-conscious about the appearance of their hands, and a man with an obviously crippled hand often did his best to hide the disability. One or two men elected to have a stiff finger amputated, but several men preferred to keep stiff, straight fingers even if they were useless to them, partly because they did not want to lose more time from work through another operation, but also because they did not like the idea of having an obviously defective hand. Two men felt there was a prejudice against disabled men where they worked, and consequently they did not want to have any obvious disability. The men disliked ugly amputation stumps or rough graft areas. Some were sickened by the feel of the graft, and one man was troubled because his wife was upset by the sight of his thumb nail growing like a piece of thin wire through a hole the size of a pin head at the edge of the graft area.

One man reacted in a neurotic manner to his injury, but he was the only man in the series whose residual disability was out of all proportion to the injury.

Case 7.—This man, a miner, lacerated the left index finger and three months later he returned to the clinic with a painful scar, and he appeared to be suffering from causalgia. By the end of two years he had had all the recognized methods of treatment except amputation, and this was considered inadvisable. When he was visited two and a half years after the accident there appeared to be nothing wrong with the finger, but he complained that whenever he bent it he felt a pain shooting up the arm, down the spine, at the back of the head and in the stomach, and sometimes the pain was so severe that he was " paralysed ". At one time he thought the pain was giving him chest trouble, and he persuaded his doctor to let him have a chest radiograph. The pain was very real to this man, and, in its own way, his condition was a genuine one. He had changed his job from work on the rolley way to datal work on the conveyor belt at a weekly loss of £2 or £3, and he was not therefore likely to gain anything financially by prolonging his illness. According to the manager at his pit, in the past he had been a good workman, but after his injury the man said that even light work was almost too much for him as he was often " in agony " and, had to let his mates take over for him. Altogether he was off work for one year and ten months because of his injured. finger. He was constantly appealing for an increase to his disability assessment, and when he was last heard of three years after the accident he was still battling with the Ministry of Pensions and National Insurance.

The Occupational and Social Effects of the Injury

Forty-seven of the 65 men who had changed their jobs were visited. Twenty-eight were still not back at their former employment, and of these five men had changed their work for reasons which were not connected with the injury, and one man was fit enough to do his old job but his firm was not willing to give him his old job back as he was not a good worker. Twenty-two men (7%) were unable to do their pre-injury job because of hand disabilities. Eight of these men had gross disabilities affecting the whole hand, and these men all changed to jobs which were virtually one handed, *e.g.*, operating the conveyor belt buttons down a pit, supervising others, or doing storekeeping work. One man found he could lay linoleum using his crippled hand as a clamp and getting a work mate to help him with anything he could not manage himself. Others found that stiff or painful fingers, especially thumbs and index fingers, were a great handicap since the hand grip was impaired, and they were often unable to pick up small objects or to use hand tools because of these disabilities. Some men were too slow to stand the pace of a machine or to keep up with a team, and others said they were nervous of machines since their accident. Three men had changed their jobs because they used to do outside work, and cold weather made their hands unbearably painful. Six men left the firms they used to work for, and with one exception they all found new work on their own initiative. The exception was a bakery worker who became unemployed because his firm could not give him suitable work, and he was referred to the Disablement Resettlement Officer of the Ministry of Labour. On the whole, employers were good at finding suitable jobs for their disabled workers. One man was told that he must register as disabled before he could be given a light job, but once he had done this there was no difficulty in finding him work he could do.

A severely disabled hand may affect a man's life in many ways, and several men were handicapped in their hobbies although they could manage their jobs all right. Some had had to cut down on their gardening activities, either because they were no longer able to feel or pick up small objects or they had not the grip to use garden implements. Several men were no longer able to play musical instruments. Basket making, embroidery, upholstery work, motor cycling, table tennis, and body building exercises, were all activities which the men found they could no longer do. Barclay (1955a) found that patients with finger tip injuries were often unable to do up their studs and buttons, and a few of the men in the present series complained of the same difficulty, usually because of stiffness or soreness of the index or middle fingers.

In general the men adjusted themselves to their disabilities remarkably well. It is seldom necessary to use any particular finger or part of the hand, and several of the men adapted the function of the injured hand so that the injured part was not used.

Discussion

The evidence of the present study indicates that although injuries to the hand often cause severe permanent physical disabilities, there is not often any occupational handicap. All but 10 of the 100 men who were visited had some kind of disability, and it is reasonable to suppose that there was a similar proportion of disabilities among the severely injured men who were not visited. But in the series as a whole only 33 men made a permanent change of work and at least five of these changed their jobs for reasons which were not connected with the injury. All the men were able to find work of some sort and only one man experienced any kind of difficulty in finding a job.

Hand injuries are important chiefly because of their frequency and of their cost. It is not possible to say how many industrial accidents involve injuries to the hand but estimates indicate that the figure must be a high one. Rank and Wakefield (1953) quote figures showing that approximately one in every three persons drawing industrial injury benefit in this country in 1949 did so for a hand injury. A more recent estimate from the Ministry of Pensions and National Insurance states that out of a total of 741,000 spells of injury benefit in 1951 there were 154,000 spells (21%), caused by hand injuries *i.e.*, approximately one in five. The incidence of hand accidents varies from industry to industry and the present study suggests that liability to serious hand accidents is particularly great in the pits and in industries using machinery, especially woodworking machinery. It is clear that the cost of these injuries is considerable, both to the community and to the individual. People with injured hands pay a high cost in terms of pain and disability. Heavy damages are often paid to men involved in hand accidents, and in 1951 the annual cost to the country in injury benefit paid for hand injuries was approximately £2·2 million. Work is held up and disorganized when accidents happen, and production is lost when a man has to be off work. Many hand accidents are avoidable, and industry would profit if more attention were paid to the causes and prevention of injuries to the hand.

Summary

The aims of the research were first, to find out the causes of hand injuries and to discuss ways of preventing them ; secondly, to find out how much time and money were lost through hand injuries ; and thirdly, to assess the long-term effects of the injuries.

The men interviewed were attending the Hand Clinic of the Department of Surgery in the Royal Victoria Infirmary, Newcastle upon Tyne. Two hundred and ninety-seven men were interviewed during the period from March, 1952, until December, 1952.

Three-quarters of the injuries were to the fingers only. The injuries were all severe enough to keep the men off work.

About a third of the injuries were caused by machinery, and most of these accidents happened to workers in the engineering and woodworking trades. Handling goods ranked next in importance as a cause of injury, and in the pits the main causes of injury were falls of stone, and moving tubs or trams.

Speed of working, inadequately guarded or badly maintained machines, faulty material, inexperience, and misunderstanding were given as reasons for accidents happening. Miners suggested that haulage accidents would be prevented if tub buffers were lengthened.

Weekly income loss while the injured man was off work varied around a mid-point of £3 10s., but this loss was often made up later if the man received disablement benefit, tax relief, or damages.

Over three-fifths of the men were off work for less than eight weeks and the median duration for all the men was seven weeks. Over half the men who had been advised to start work by the clinic surgeon delayed doing so for two weeks or more. Sixty-five men went back to different jobs, but 27 of these later returned to their own work. Thirty-three men were known to have made a permanent change of employment.

One hundred of the more severely injured men were visited at home about two years after the injury. All but 10 of these men had some degree of residual disability. An attempt was made to assess the occupational, social, and psychological effects of the injuries. Physical disabilities were often severe but there was rarely any occupational handicap.

I wish to thank Professor R. C. Browne for his advice and general help throughout the work, and also to acknowledge the statistical assistance given by Mr. D. Newell and Mr. H. Campbell. I am very grateful to Mr. Dennis Newman, statistician to the Ministry of Pensions and National Insurance, and his staff for producing the official figures for the incidence of hand injuries. The work was made possible by the help and interest received from the staff and patients of the Hand Clinic of the Department of Surgery in the Royal Victoria Infirmary, Newcastle upon Tyne. I am also greatly indebted to Mrs. M. Berry for secretarial assistance, and to Mrs. D. Weightman for her help with the calculations.

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THE JANUARY (1956) ISSUE

The January (1956) issue contains the following papers :—

The Prevalence of Pneumoconiosis and Tuberculosis among Earthenware Towers. By E. Posner.

A Report on the Absence of Pneumoconiosis among Workers in Pure Limestone. By S. Bridge Davis and G. Nagelschmidt.

Further Studies of the Dust in Lungs of Coal-miners. By E. J. King, B. A. Maguire, and G. Nagelschmidt.

Cardiac Hypertrophy in Coalworkers' Pneumoconiosis. By W. R. L. James and Arthur J. Thomas.

Respiratory Function in Men Casting Cadmium Alloys.

Part I : Assessment of Ventilatory Function. By G. Kazantzis.

Part II : The Estimation of the Total Lung Volume, its Subdivisions, and the Mixing Coefficient. By R. St. J. Buxton.

The Action of Variable Amounts of Tridymite, and of Tridymite Combined with Coal, on the Lungs of Rats. By Daphne Attygalle, E. J. King, C. V. Harrison, and G. Nagelschmidt.

Toxicological Investigations on Dimethylformamide. By W. Massmann.

Dermatitis from Mansonia Wood. By L. B. Bourne.

A Survey of Dock Labour Accidents in the Port of London. By W. J. Shaw.

Miscellanea :

A Study of Variations in Output. By I. M. Richardson and W. Z. Billewicz.

Shell Haven Medical Centre. By Gunilla Liddle.

British Occupational Hygiene Society :

The Use and Abuse of Protective Equipment. By C. N. Davies

Report of Ordinary Scientific Meeting

Obituary : Carl M. Peterson, M.D.

Book Reviews

A number of copies are still available and may be obtained from the Publishing Manager, British Medical Association, Tavistock Square, W.C.1, price 12s. 6d.

Brit. J. industr. Med., 1956, **13**, 131.

CONSISTENCY AND CAR DRIVING SKILL

BY

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It seems likely that when a man is learning a new skill he tends to correct for mistakes by going too far in the opposite direction. Lashley (1951) mentions for example that after an inexperienced typist has made an error he may even over-compensate to the extent of repeating the letter previously omitted. The learner proceeds by a series of oscillations about the ideal which may itself vary with the individual when skilled manual behaviour is under consideration. Improvement in skill may be accompanied by a reduction in the size of these oscillations. For instance, in learning to ride a bicycle, the wild wobble is gradually replaced by almost invisible movements. Bartlett (1951) has remarked that " notable irregularities in a pattern of control movements are the surest sign of awkwardness in skill ". Again, with reference to the skilled operator, " What is impressive is the absence of any appearance of hurry. There is no jerkiness or snatching, no obvious racing to catch up in one part and forced sauntering to make up in another " (Bartlett, 1947).

Ashby (1952) has shown how a homeostatic machine when disturbed will oscillate in decreasing rhythms until it has established a new equilibrium with the stimulus, when its response will be minimal ; " under constant stimulation the response has diminished ". It is probable that there are some resemblances between the mechanisms of the human learning process and such machines.

If we can examine the performance of skilled and unskilled people on a given task the most noticeable difference might be that the skilled performance is sufficiently regular to be reproduced on another occasion provided that extraneous random factors can be kept at a minimum. When dealing with an activity such as driving a car, it is difficult to obtain any absolute criterion of errors, but any lack of consistency within the work from a given man can be directly studied. The following experiments consider the performance of groups of drivers, classified as skilled or unskilled, during a standard driving task. This involved taking corners in the absence of any other traffic. Records were kept of the performance of these 30 men over the course on two different occasions separated by six weeks. Particular attention was paid to the acceleration records. While there can be no ideal method of taking such a course, it seems likely that the skilled driver will have a pattern of behaviour for a given situation which experience has taught him is the best. Thus the skilled driver may show a smoother curve of acceleration and deceleration and a further attempt may lead to a pattern of activity which resembles the previous curve.

Procedure

The Test Course.—An airfield with runways forming an equilateral triangle and having a good driving surface was used for the trials. The inner side of the runways (15 ft. wide lanes) formed the " roads " ; the limits of the road at two corners around each of which a turn of 120 degrees had to be made, were marked with surveyors' posts (Fig. 1). At a point 150 yards before and after

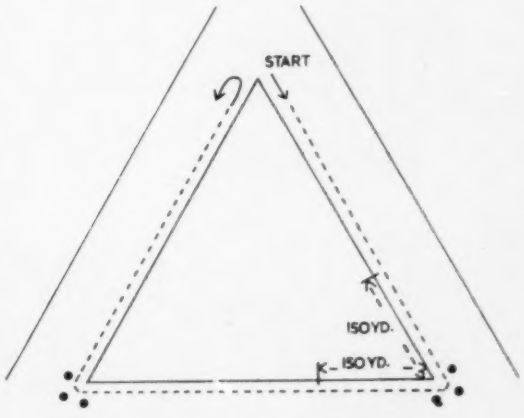

FIG. 1.—Test corners through 120° on airfield runways.

each corner a mark, recognizable by the passing observer, was painted on the runway edge.

Apparatus.—The experimental car was a series E, 1947 Morris 10 Saloon. A recording apparatus was constructed to enable a photograph to be taken by the forward-facing single-shot camera once every five yards of distance travelled, regardless of speed. (This camera viewed through the windscreen and each frame showed the dashboard instruments, including a Tapley performance meter* set to zero on level ground, see Fig. 2.)

Subjects.—The Chief Driving Instructor of the Essex County Police Advanced Driving School was asked to select three groups of drivers.

Ten Skilled Police Driving Instructors or Motor Patrol Drivers.—These drivers in Group 1 were known to possess exceptional driving ability and were considered to represent the best standards of police driving.

Ten Skilled Rally Drivers, not Police Trained.—The skilled men in this group were keen car club drivers. They were enthusiastic enough to spend most week-ends practising for or participating in club or rally events, in which behaviour and skill played an important part.

They cannot be regarded as having quite the polish of the skilled police driver, but as a group they represent the normal civilian driving community at a level " well above average ".

Ten Unskilled Drivers.—All of these drivers had, however, driven for at least three years; the unskilled men were considered, purely on opinion and not because of any accident record, to drive in a manner well below the average. They were mainly employed as civilians in duties associated with vehicle maintenance and drove light transport in the course of their work.

Experience.—All the drivers were men and their ages ranged between 21 and 54 years. The police group averaged 35 years, and the others 40 years. All the drivers had held a full driving licence for at least three years. At the time of the test the police drivers were driving more regularly than the other men.

Instructions.—Before starting the initial test subjects were briefed on the layout of the experimental car. They were then asked to practise driving the car and to familiarize themselves with the gears, clutch, brake, etc., until they were completely at ease. They then drove to the first corner to be negotiated in the test and parked close to it, in a position allowing a clear view of (*a*) the approach to the corner, (*b*) the corner, and (*c*) the drive away from the corner. The following instructions were then given :—

" The car is now pointing in the direction from which you will start your drive. You have a half-mile approach to this corner along the 15 ft. straight lane. The corner you see clearly marked by posts is rather sharp. I would like you to drive comfortably, approach the corner, turn it, and then drive away. You must keep within the limits of the 15 ft. road. Some distance after the corner there is another exactly the same. Turn this also and then after you have driven away from it I will tell you where to turn around. We then drive back, turning the same corners to the left. Are there any questions ? "

Questions were asked by a number of drivers in each group and were answered in full, with the exception of those relating to speed or time allowed ; in these cases it was reiterated that the only requirement was to drive " comfortably ".

The subject then drove to the starting point for the run (Fig. 1) and began his approach to the first corner.

As the mark 150 yards before the corner was passed, the experimenter seated in the rear nearside passenger seat switched on the camera, which, as stated previously, photographed the road ahead and the instruments once every five yards. At the mark 150 yards after the corner the camera was switched off.

This procedure was repeated for all four corners.

The Retest.—Instructions were repeated for all subjects six weeks later, when exactly the same test was run through again. None of the subjects knew that this repeat run was to be an exact repetition of the first test.

Methods of Analysis.—The film records of acceleration were analysed frame-by-frame and the 61 readings obtained over 300 yards at 5-yard intervals were recorded for each corner.

Use was made of accelerometer readings rather than velocity readings because they reflect more directly what the

* The Tapley performance meter is a damped accelerometer; readings are shown in lb. per ton to a maximum of ± 650 lb. per ton, or nearly one-third " g ". The instrument was read to the nearest 10 lb.

FIG. 2.—Photograph by the recording camera.

subject is doing with the controls, which are acceleration controls rather than direct velocity controls. Therefore these acceleration readings have been adopted although at first sight it might seem that they could have been calculated from the simple velocity-time record.

For each subject it was possible to plot a performance graph for each of four corners for the first occasion of the test; over this was superimposed the performance graph for the same corner negotiated six weeks later (Fig. 3).

The area difference between these curves was obtained by calculating the sum of the differences between corresponding "5-yard" acceleration scores for the test and retest curves. This sum was taken as the index of lack of consistency. Separate totals were calculated for the approach half and departure half of each corner. In this way eight inconsistency scores over the six-week period were calculated for each subject. Same-day inconsistency scores were also obtained for both the test and the retest days by comparing the two consecutive curves for the right hand corners and the two consecutive curves for the left hand corners.

Results

Consistency with the Six-Week Interval.—The performance graphs of all trials made in the course of the experiment are shown in Figs. 5, 6, and 7. Fig. 4 summarizes the evidence.

By analysis of variance the comparison between the three groups showed a highly significant difference between the mean consistency scores for the three groups (Appendix).

Individual comparisons between pairs of groups showed no significant difference between police and rally drivers, but differences between the unskilled and each of the remaining two groups were found to be significant at the 0·001 level. The mean inconsistency scores for the police, rally, and unskilled groups were 108, 114, and 156 respectively, as will be clear from Table 1 and Fig. 4.

FIG. 3.—Key to miniature graphs (Figs. 5, 6, and 7).

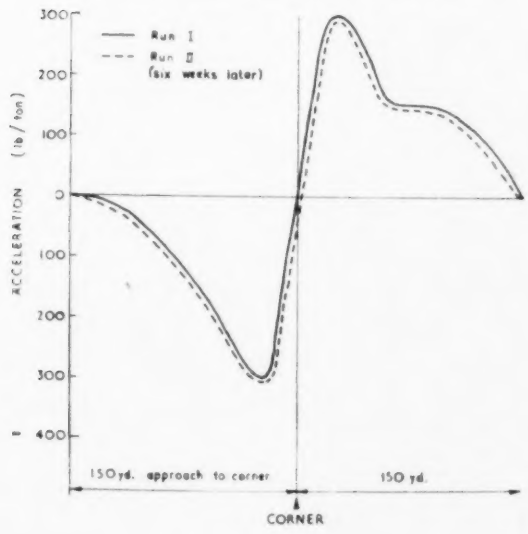

FIG. 4.—Consistency scores for acceleration data from skilled and unskilled drivers.

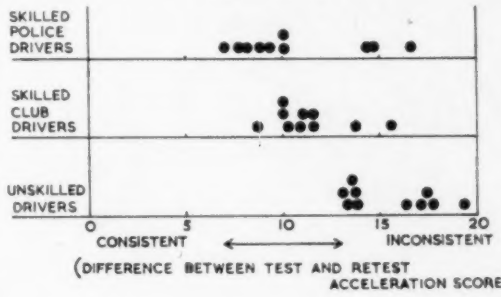

TABLE 1

INDIVIDUAL INCONSISTENCY SCORES

Skilled Police Drivers	Skilled Rally Drivers	Unskilled Drivers
71	87	131
79	100	134
82	100	136
89	102	138
93	109	139
101	111	163
101	116	172
145	117	176
148	139	179
168	156	194
Means 108	114	156

The marked difference between individuals in the police group may be attributed to the poor consistency scores of three subjects whose scores departed from the level established by the majority in this group. On the retest these three drivers approached the corners at a very different speed from their speed on the first test, whereas the remaining drivers tended to approach at the same speed on the two occasions.

Consistency for the unskilled group appears from Fig. 6 to be poorer before the corners than after. This result is possibly due to the expected difficulties imposed by the approaching corner. The acceleration curves for the approach vary considerably between and within the drivers in the unskilled group, whereas after the corners the attempts are more homogeneous. No differences between left and right corners were found.

Inconsistency within the Same Day.—A further analysis of variance was carried out on the scores of inconsistency between consecutive corners within *one* day for the three groups. No statistically signi-

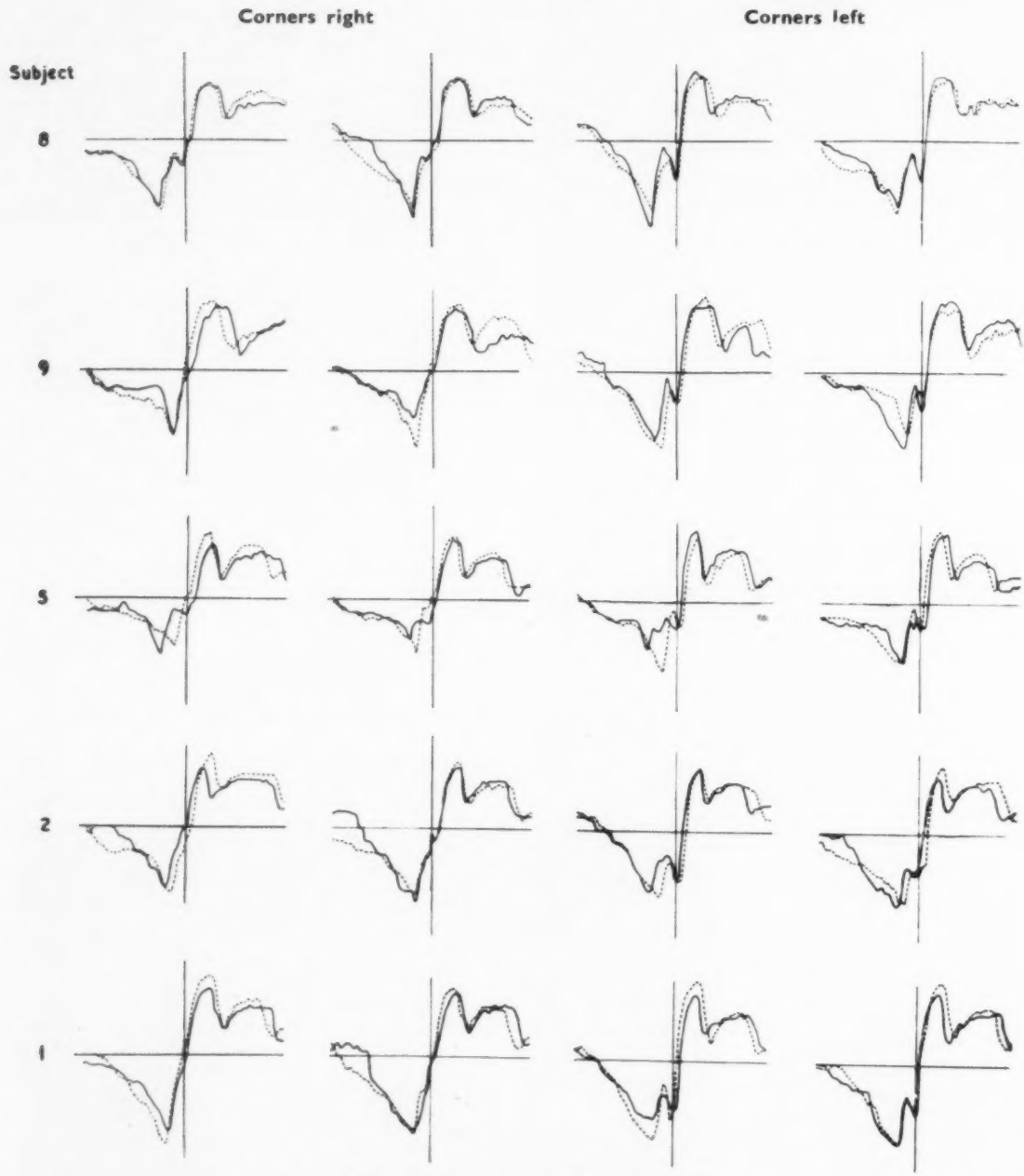

FIG. 5.—Graph of performance of skilled police drivers.

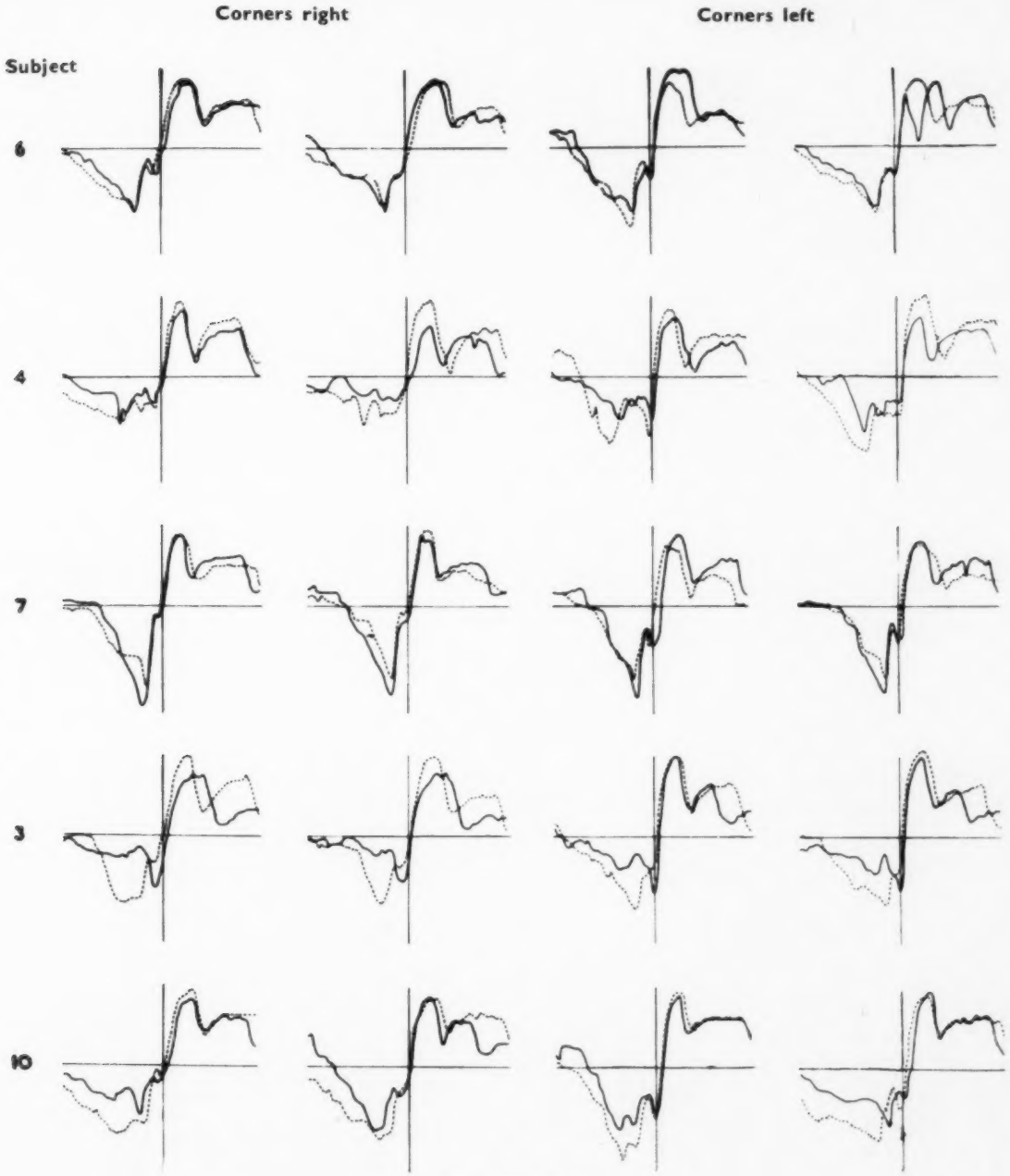

FIG. 5.—*continued.*

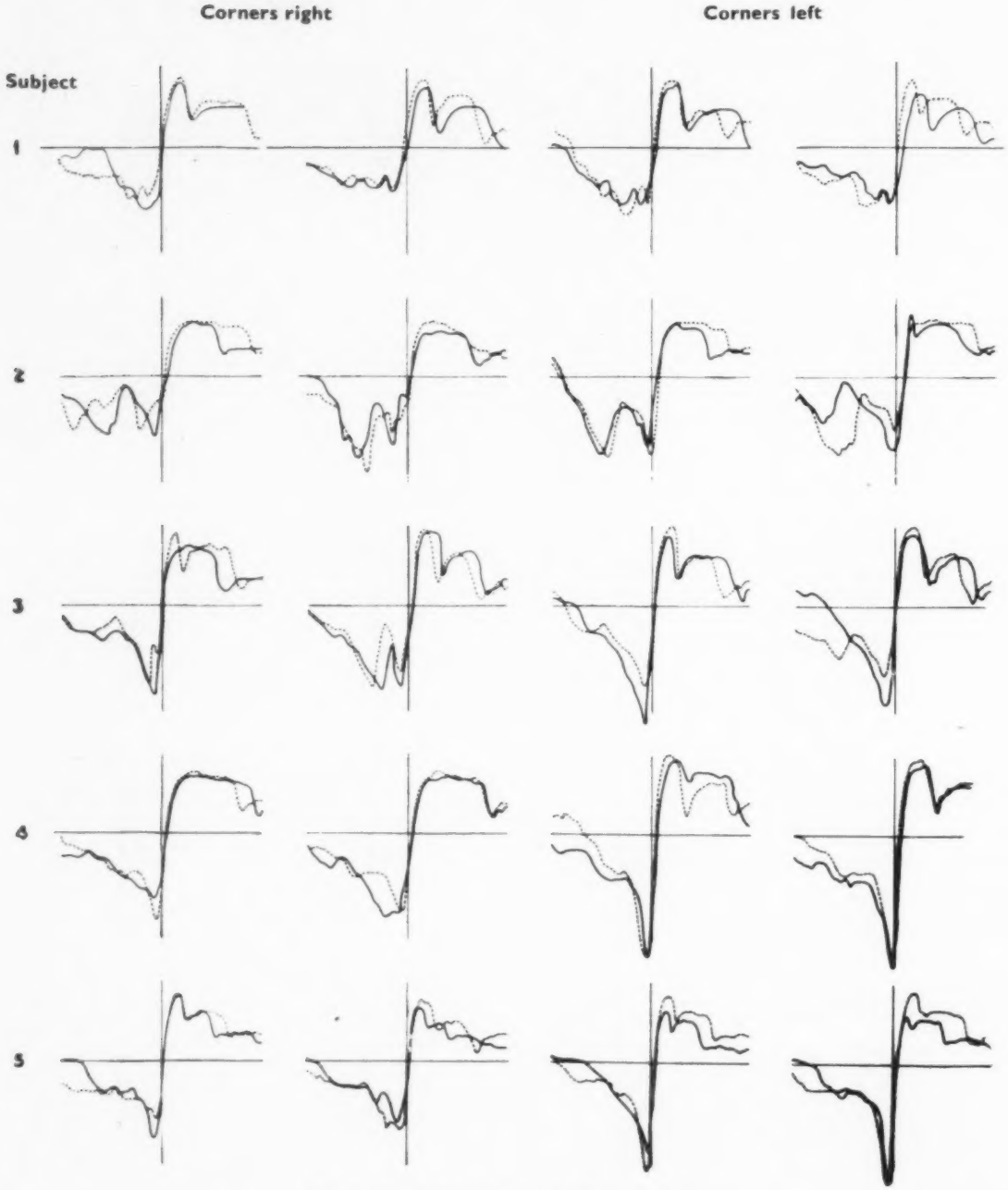

FIG. 6.—Graph of performance of skilled rally drivers.

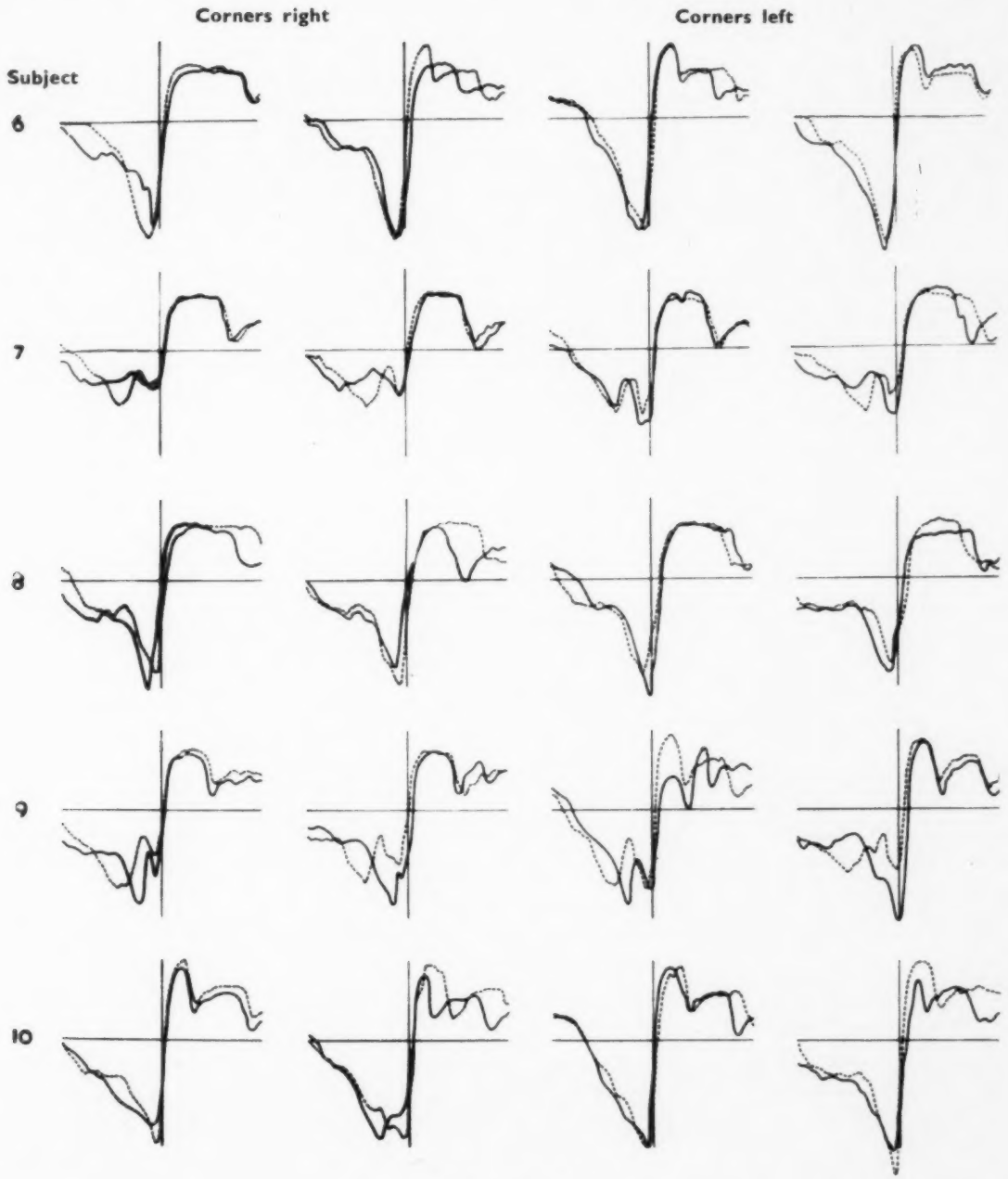

FIG. 6.—*continued.*

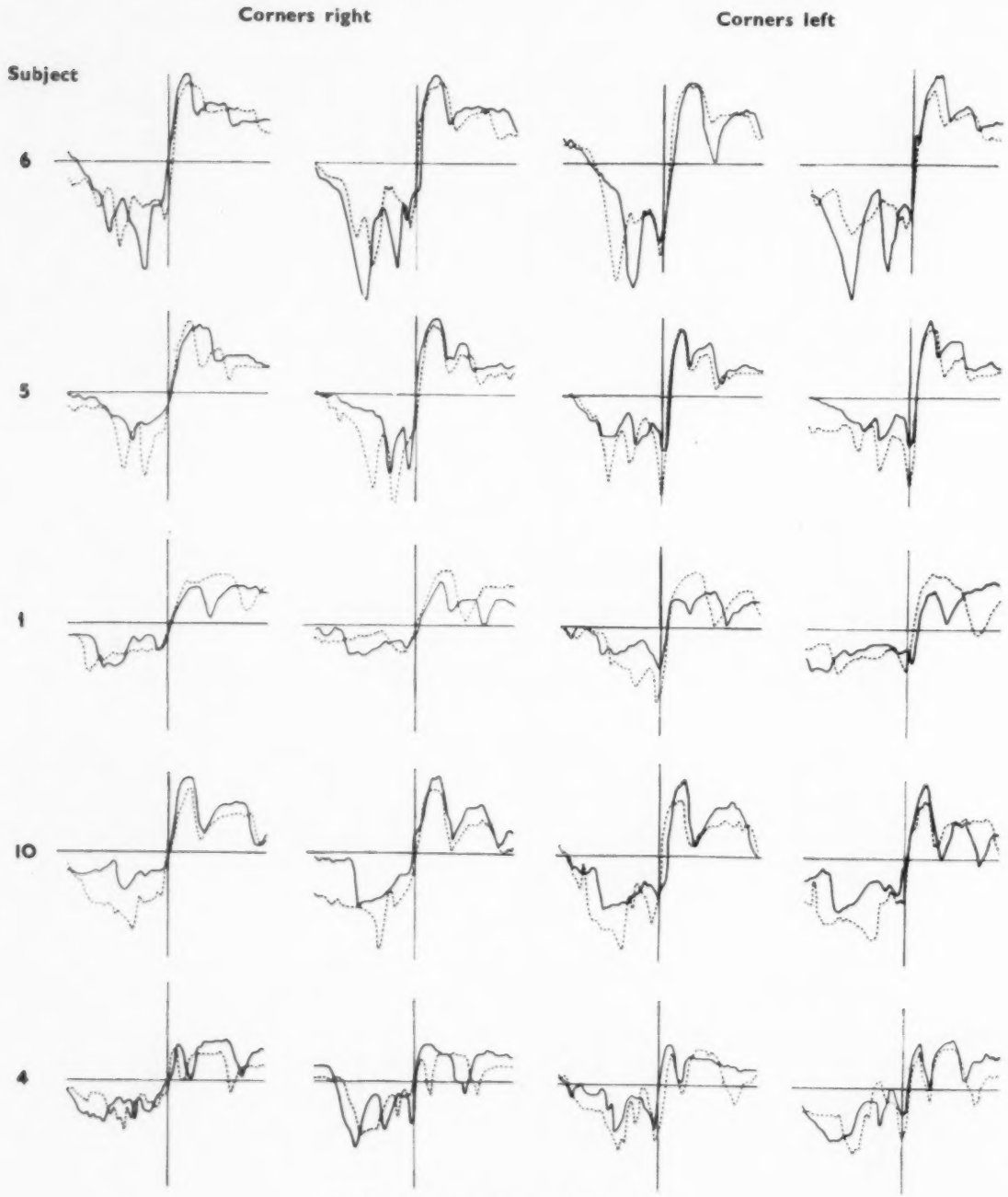

FIG. 7.—Graph of performance of unskilled drivers.

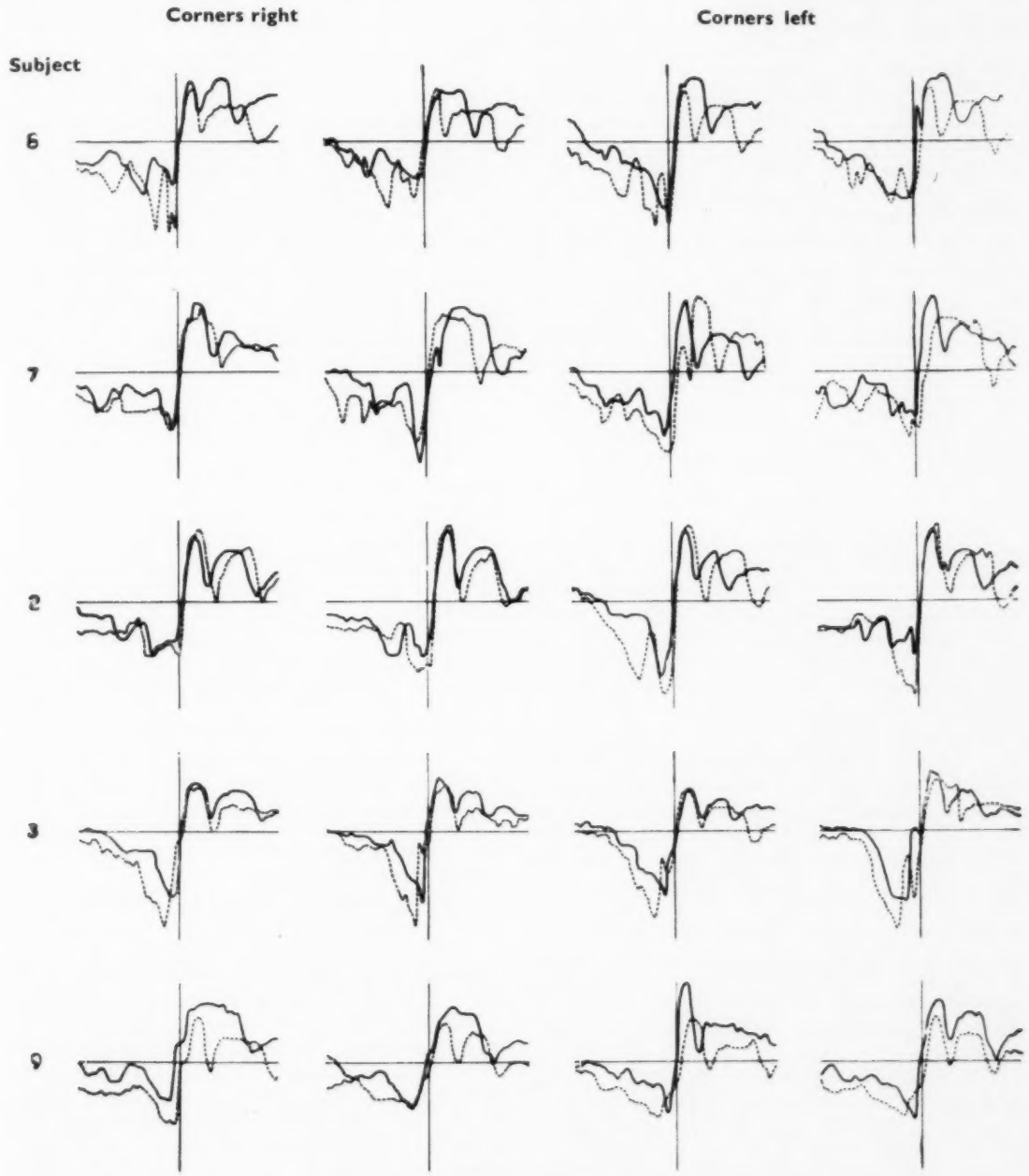

FIG. 7.—*continued*

ficant differences were found between groups although the unskilled drivers still appeared to be the least consistent. In spite of the fact that they seemed at times to repeat their mistakes, *e.g.*, misjudgment of deceleration requirements before the corner, the differences between test and retest were higher than those of the other drivers, because they often made the same mistakes at different stages in the approach to the corner.

The police and unskilled groups showed a significantly lower inconsistency score within the same day than when a six-week interval elapsed between test and retest (Table 2). The tendency was apparently the same for the skilled rally drivers, but this was not a reliable statistical difference.

TABLE 2
MEAN SCORES OF INCONSISTENCY

Group	Same Day	Six Weeks
Skilled police drivers	91	108
Skilled rally drivers	107	114
Unskilled drivers	120	156

Discussion

The changes in behaviour occurring with different time intervals between test and retest are not easily explained. There are many factors likely to change behaviour when response is made to identical stimuli and the time interval between test and retest is great. In this experiment we have disregarded the conditions and stresses of life to which all our subjects were exposed during the six-week interval between test and retest. In spite of this we have found that over this period the behaviour of skilled drivers during cornering trials was little changed. It was surprising how consistent a really skilled man could be in these circumstances. It appears that what happens to a skilled man between tests may have little effect on his performance in a well-established skill. It has been shown by Tillmann and Hobbs (1949) in work on the accident-prone driver that living habits are associated with vehicle driving performance. The statement " we drive as we live " may well be true, for daily examples can be seen of personality reflected in performance in skill and sport.

The personality of the drivers who acted as subjects for this experiment was examined by Venables (1955) who gave tests to a number of drivers in each of the three groups. These tests sought neurotic or anxiety-hysteria traits. The main differences between groups indicated that the scores of the police and rally groups all lay within the normal range ; in the unskilled group, four of the six scores obtained were tending toward the neurotic end of the scale. This suggested some relationship between lack of consistency in test-retest scores and neurotic personality ; but it must not be supposed that any such relationship can be regarded as established.

Though the main differences between groups in the actual driving trials were in terms of consistency, interesting differences were also observed in the acceleration patterns. Clear differences were found between groups in the manner in which corners were approached (see Figs. 5, 6, and 7). The police group appeared to decide to decelerate from a point about 150 yards from the corner. The deceleration generally continued smoothly until a peak deceleration was reached and the car was then accelerated around and away from the corner. This procedure was usual with most of the police group (Fig. 5) and probably reflected the standard training methods of the police driving schools. The rally group differed between themselves, although in general they have approach patterns similar to those of the police. These differences between rally drivers may have resulted from varying methods of instruction. The unskilled group (Fig. 7) show frequent reversals in their approach acceleration patterns, perhaps due to their inability to make correct decisions when confronted with the approaching corner. This demonstrates clearly the role of anticipation in skill as discussed by Oldfield (1952).

Though interesting, these single trial patterns do not lend themselves conveniently to any analysis that seeks to distinguish between groups of skilled and unskilled drivers, for some of the unskilled drivers do not show reversals but are nevertheless inconsistent. It is here that the possible value of consistency measures lies, for this technique enables an estimate to be made of a man's performance against his own standards.

Thus consistency measures may be related to the level of experience or training. It is also possible that if examined from the consistency viewpoint, measures of performance might be of value at an early stage in training in predicting the eventual level of skill likely to be achieved. In conclusion, there would seem to be many further applications of the consistency measure that could be made in the course of experiments dealing with fatigue, stress, and ageing. The optimum test-retest interval will presumably vary with the test and should be determined in each case.

Summary

The paper considers whether consistency in performance between two occasions of test separated

by a six-week interval is related to skill in driving. Evidence is presented which suggests the value of this approach to measuring skill; the general importance of the finding is that this method of assessment can be used even in cases where there are many different ways of doing the given task.

Cornering trials were performed by three groups of drivers on an aerodrome without any traffic. The comparisons were between (*a*) skilled police drivers, (b) skilled rally drivers who had been given no standard training, and (*c*) unskilled drivers. The skill of these 30 drivers was assessed by the same chief police driving instructor and the three groups were made up for study according to his views.

After a great deal of trial and error it was found that the most promising measure was that of vehicle acceleration and deceleration. Readings of acceleration/deceleration were therefore recorded photographically every 5 yards over a distance of 150 yards before and after each of the four corners in the test run. An exactly similar run was given six weeks later to the same 30 drivers.

Scores of consistency were calculated for each subject over the six-week interval and it was found that those in both skilled groups, police-trained and self-trained, were significantly more consistent than were the unskilled drivers.

Although test-retest consistency gave differences between the three groups when test and retest were separated by an interval of six weeks, the same group differences in consistency did not show when consistency between consecutive corners was considered within the same day. The optimum test-retest interval to reveal the differences between good and bad drivers clearly needs further detailed consideration.

This work was carried out under the direction and guidance of Sir Frederic Bartlett, F.R.S., and Dr. N. H. Mackworth. Mr. Eric Farmer initiated this series of experiments whilst Chairman of the Road User Committee. The staff of the Road Research Laboratory has also given assistance.

Miss Violet Cane advised on statistical problems and directed Mr. Goodhardt in his work on the complete statistical analysis.

It is a pleasure to thank Captain Peel, Chief Constable of the Essex County Constabulary, for the facilities he provided, and Inspector F. R. Priestley, the Chief Driving Instructor of the Essex County Police Advanced Driving School, who spared no effort in ensuring that the experiment proceeded smoothly.

Messrs. Co-Partnership Farms Limited, Boreham, were kind enough to allow us to use their airfield.

Finally, I wish to thank the 30 drivers, police and civilian, who drove so keenly as subjects and made the experiment possible.

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APPENDIX

ANALYSIS OF VARIANCE POOLED FOR THREE GROUPS

	D.F.	S.O.S.	Mean Square	V.R.	5% Level	1% Level
Between groups	2	19,850,011	9,925,005	11·94	3·35	5·49
Pooled between subjects	27	22,437,287	831,011	—	—	—
Between conditions *	3	2,514,438	838,146	4·30	2·76	4·13
Conditions × groups	6	1,503,406	250,568	1·28	2·17	—
Between corners †	1	492,320	492,320	2·52	3·92	—
Corners × groups	2	575,261	287,630	1·47	3·07	—
Pooled corners × conditions	9	3,297,954	—	—	—	—
Pooled corners × subjects	27	5,058,140	—	—	—	—
Pooled conditions × subjects	81	35,147,052	—	—	—	—
Pooled residual within subjects	81	15,799,375	195,054	—	—	—
Total	239	106,675,244	—	—	—	—

*The four "conditions" are the approaches to the two left hand corners, the departures from these two corners, and the approaches to and departures from the two right hand corners.

† The term "between corners" indicates a comparison between the two runway corners used, when for each corner the score for the outward right hand turn was added to the score for the return left hand turn.

MISCELLANEA

John Darwall, M.D. (1796-1833) and "Diseases of Artisans"

A. MEIKLEJOHN

From the University of Glasgow

Since the commencement of the factory system in Great Britain, Birmingham has been a leading centre of manufactures. Throughout this period the industries have been many and various but particularly in the metal trades. In these circumstances it is not surprising that local medical practitioners have shown special interest in diseases of artisans. Indeed in the modern advance of industrial medicine Birmingham has made an outstanding contribution.

Among the early writers in English on trade diseases it is customary to give pride of place to Charles Turner Thackrah of Leeds, whose pamphlet on "The Effects of the Principal Arts, Trades and Professions and of Civic States and Habits of Living on Health and Longevity with a Particular Reference to the Trades and Manufactures of Leeds" was first published in 1831. Ten years earlier, in 1821, Dr. John Darwall, a physician of Birmingham, presented a thesis to the University of Edinburgh, entitled "Diseases of Artisans with Particular Reference to the Inhabitants of Birmingham". As a contribution to the literature of trade diseases the discourse has no great merit, but as an early historical document it seems worthy of record, which, so far as I can discover, it has not hitherto obtained. As was the custom of the time the thesis is written in Latin. I have translated it and in this exercise I have been assisted by reference to the terminology in an article entitled "Diseases of Artisans" which Darwall contributed to the "Cyclopaedia of Practical Medicine" in 1833.

Biographical Note

John Darwall, the son of the Rev. John Darwall, was born at Deritend in 1796. He was educated at the Free Grammar School in Birmingham under the Rev. John Cooke. In 1813 he became the pupil and apprentice of Mr. George Freer of Birmingham, one of the most distinguished provincial surgeons of his time. He was a very diligent medical pupil and, as revealed by his notebooks, was by no means inattentive to general science and literature. On completion of his apprenticeship, at the age of 20, he went, in October 1816, to London to attend the hospitals and lectures. During this period he was deeply influenced by the teaching of Mr. Abernethy. In May, 1817, he was admitted a member of the College of Surgeons. The following autumn not content, as is recorded, with the superficial manner in which medicine was, at that time, taught in London, he went to Edinburgh. There he studied physic under Gregory, anatomy under Monro and Barclay, and physiology under Gordon. At the end of the winter he returned to Birmingham as an assistant to Dr. Freer with whom he continued until 1819. During this period he became interested in the diseases of workpeople and in their places of work. In 1820 he returned to Edinburgh and in that year read a paper on the subject to the Medical Society. The following year he presented his thesis, entitled *De Morbis Artificum*, for the degree of doctor of

DISSERTATIO MEDICA

INAUGURALIS,

DE

MORBIS ARTIFICUM,

PRÆCIPUE

EORUM QUI BIRMINGHAMIÆ HABITANT:

QUAM,

ANNUENTE SUMMO NUMINE,

ET AUCTORITATE REVERENDI ADMODUM VIRI,

D. GEORGII BAIRD, SS. T. P.

ACADEMIÆ EDINBURGENÆ PRÆFECTI,

NECNON

AMPLISSIMI SENATUS ACADEMICI CONSENSU, ET

NOBILISSIMÆ FACULTATIS MEDICÆ DECRETO,

Pro Gradu Doctoris,

SUMMISQUE IN MEDICINA HONORIBUS AC PRIVILEGIIS

RITE ET LEGITIME CONSEQUENDIS,

EXCUDITORUM EXAMINI SUBJICIT

JOANNES DARWALL,

Anglus;

COLL. REG. CHIR. LOND. SOC.

NECNON SOCIET. REG. MED. EDIN. SOCIUS EXIM.

Utile est scire unumquemque, quid et quando caveat.—CELSUS *Praefat. ad Libr. 2.*

Kalendis Augusti, horâ locoque solitis.

EDINBURGI:

EXCUDEBAT JOANNES MOIR.

MDCCCXXI.

medicine, which he obtained in August, 1821. Immediately after the graduation he returned to Birmingham where he obtained an appointment as one of the physicians to the Birmingham Dispensary. This work was mainly concerned with the care of poor-law patients. His interest was in medicine rather than in surgery and in addition he was attracted to medical journalism. Each quarter he contributed a "Report of Diseases of Birmingham" to the *Edinburgh Medical and Surgical Journal*. Later he assisted Dr. W. Copland, the editor of the *London Medical Repository*. He contributed papers on dropsy and spinal and cerebral irritation and on many

* It is expedient for all men to know what precautions to take and when.

other subjects. In particular he was known for his forthright critical and analytical reviews. For a time he was joint editor with Dr. Charles Hastings of Worcester of the *Midland Medical and Surgical Reporter*.

He published, in 1830, a small volume entitled " Plain Instructions for the Management of Infants together with an essay on Spinal and Cerebral Irritation ". The following year he achieved his great ambition when he was appointed physician to the Birmingham Hospital.

In 1833 he contributed a well-considered article on " Diseases of Artisans " to the first volume of the " Cyclopaedia of Practical Medicine ".

At the early age of 37 years he died under rather tragic circumstances. According to his hospital notebook, on July 30, 1833, he performed a post-mortem examination on a case headed : " Medullary Sarcoma of the Bronchial Glands ". The left lung was infiltrated with pus and it would appear that in the course of the dissection he infected a small wound in his left hand. The same night he fell ill with acute fever. Despite the unremitting efforts of his colleagues he died and was buried on August 16, in the family vault at Christ Church, Birmingham.

I am deeply indebted to the University of Edinburgh for permission to publish the thesis and the translation together with the photograph of the original frontispiece ; also to John A. H. Way, M.A., the Humanity Department in the University of Glasgow, who edited the translation and elucidated many passages.

" Diseases of Artisans with Particular Reference to the Inhabitants of Birmingham "

By JOHN DARWALL

When the world was still new and the inhabitants few, there was scarcely any form of labour apart from agriculture. It is probable also that diseases, like crafts, were equally few. But later when the population was divided into various trades, although some of these may have led to luxury and a comfortable life, diseases likewise increased to the greatest degree. For either the method of work or the materials used in the work—harmful in themselves—frequently caused illness among the tradesmen. But it seems surprising that amongst the researches of learning and humanity, very few have inquired into the hardships of tradesmen and even fewer have attempted to relieve the hardships which have been discovered.

As the subject of my discourse the Royal Medical Society prescribed " The Diseases of Artisans ". During the summer of 1820, while resident in Birmingham, I frequently inspected the factories and homes of these workmen and questioned them personally on the subject of their health. On these occasions I personally collected certain facts about the diseases of artisans which appeared to me not altogether unworthy of record. For other information I am indebted to Dr. Booth, formerly president of the Medical Society, who often accompanied me and assisted me by his advice.

Although the trades are so numerous that it is not possible for me to enumerate them all, the causes of ill-health arising from them are fewer. It is seen that immoderate toil, muscular effort, posture, excessive light and noise, variations of temperature, irritation by stone dust or other particles, and chemical irritation are the outstanding causes.

Dissertatio Medica Inauguralis de Morbis Artificum, Praecipue eorum qui Birminghamiae Habitant

AUCTORE JOANNES DARWALL

Cum mundus adhuc novus et homines in terris rari fuerunt, illis vix aliud opus erat, quàm agricultura. Probabile est etiam morbos aeque ac artes paucos fuisse. Sed post-quàm variae artes viros diviserunt, quamvis illae ad luxuriam vel commoda vitae conduxisse potuerint, morbi similiter plurimùm auxerunt. Modus enim vel operandi vel materies operis per se noxia, valetudinem adversam persaepe artificibus intulerunt. Mirabile autem inter investigationes scientiae benevolorumque animorum videtur, perpaucos mala artificum quaesivisse, perpaucissimos cognita levare conatos esse.

Mihi pro argumento sermonis, regia medica societas morbos artificum tribuit, et per aestatem anni MDCCCXX Birminghamiae habitans, officinas domusque illorum saepissimè visi, et de valetudine suâ ipsos interrogavi. Eo tempore quaedam de morbis artificum ipse collegi, quae non omnino narratione indigna mihi videbantur. Alia quoque Doctori Booth olim medicae societatis praesidi debeo, qui mihi saepe comitatus est et consilio adjuvit.

Quamvis artes tam multae sunt, ut vix enumerari possint, causae tamen valetudinis adversae ex illis orientis sunt rariores. Praecipue harum videntur esse labor immodicus, conatus muscularis, positio corporis, lux sonitusve nimius, temperiei mutationes, irritatio pulveris lapidum vel aliarum particularum, et irritatio chemica.

Immoderate Labour

The evils which derive from immoderate toil chiefly affect children. These young persons either from the poverty of their parents or, what is much more to be condemned, from the greed of employers, are compelled to work at a much lower age than is right. Scarcely three years have passed since the government of Great Britain discussed this problem, and sought the opinions of leading medical men. Of these Mr. Astley Cooper, surgeon, alone gave evidence from his personal experience. Certainly his reputation and acknowledged learning do not permit us to doubt the truth of his judgment. " The effect," said this distinguished gentleman, " which I have observed in many cases, is not only to diminish the stature but also to produce deformity of the limbs ". Robert Owen of New Lanark was questioned on the same occasion and his testimony was to the same effect.

My personal experience, if I may speak of it, fully confirms the judgment of the distinguished Mr. Cooper.

There is an institution in Birmingham in which 400 children are accommodated. Their ages vary from 1 to 14 years, but they are not compelled to go to work before the age of 7. At this age they are employed eight hours daily in many occupations and for one hour they receive instruction in the elements of education. This period of employment is certainly inconsiderable, if one compares it with the labour of adults, but even so it causes ill-effects among these children, from which they seldom completely recover. The power and ability of movement are completely lost and the height is obviously reduced. The knees, too, are often bent inwards and become weak. I have questioned some boys, who seemed to me to have scarcely reached the age of 6, about their age, but I always found that they were much older than they looked. But after my investigation in the institution, I saw not a few who formerly lived there and I did not observe a single one among them who was tall. Accordingly it appears to me that there is nothing unsound in Cooper's opinion that deformity is caused by immoderate labour.

No less definite maladies occur in adult men although they are less frequent. Sometimes these illnesses occur in the conscientious heads of families and consist of indigestion, mental depression, and debility.

But the same amount of labour is not excessive for all men for men vary just as much in strength as they do in appearance. There is, however, a limit which most men observe and in factories in Great Britain men spend 12 hours daily on work. Dr. Bailey has in fact asserted that, in his opinion, 10 hours should be adequate. It is not unusual to observe that men enjoy the greatest health when they work to their fullest capacity, which seems to occur because at the same time they earn a bigger wage and accordingly their standard of life is more favourable.

Muscular Effort

Some diseases are caused by muscular effort. The most important of these are hernia and aneurysm. Not a few injuries also result from violent effort. Paviors,

Labor Immodicus

Mala, quae e labore immodico pendent, ut plurimum in liberis apparent. Hi ab inopia parentum, vel quod multo magis vituperandum est, ex avaritiâ magistrorum, longè juniores quam aequum est, ad laborem suscipiendum coguntur. Tres anni vix elapsi sunt, cùm Senatus Britanniae Magnae de hoc considerârunt, et regni medicos principes sententias rogaverunt. Ex his ASTLEY Cooper chirurgus, solus ab experientiâ doctus, testimonium dedit. Fama vero illius viri et scientia benè agnita, nihil de veritate opinionis nos sinunt dubitare. " Effectus," inquit ille illustris, " et ex multis exemplis cognovi, non tantum staturam diminuere est, sed pravitatem etiam membrorum producere."

Eodem tempore ROBERTUS OWEN a " New Lanark," interrogatus est, et testimonium ejus ad idem propositum fuit.

Experientia mea, si aliquid de illâ dicere liceat, sententiam COOPER illustris summoperè confirmat.

Birminghamiae asylum est, in quo liberi quadringenti habitant. Aetates horum a primo ad annum quartum decimum variant, nec ad laborandum ante septimam aetatem impelluntur. Eo tempore octo horas quotidie in multis operibus exercentur, unamque horam elementa doctrinae discunt. Paululum quidèm hoc, si cum labore hominum componas, attamen malum liberis infert, ex quo admodum raro, se recipiunt. Vigor et facilitas motuum prorsus amittuntur, et statura manifestè diminuitur. Genua etiam saepe intus inflexa et imbecillia fuerunt. Aliquos pueros scrutatus sum de aetate, qui mihi vix sextum annum attigisse videbantur, semper autem inveni multo annis, quam visu seniores. Post vero scrutationem in asylo, non paucos vidi, qui in illo olim habitaverunt, et ne unum quidem procerum inter omnes observavi. Mihi ergo nihil falsi in sententiâ COOPER apparet, deformitatem elabore immodico oriri.

In hominibus maturis mala non minus certa sunt, etiamsi rariora. Aliquando in diligentibus patribus familiarum occurrunt, atque in dyspepia, demissione animi et imbecillitate consistunt.

Labor tamen non omnibus idem est immodicus, viri enim robore aeque ac facie magnoperè differunt. Modus autem adest, quem plurimi sequuntur, atque in officinis Britanniae Magnae, homines quotidie labori duodecim horas impendunt. Doctor BAILEY quidem ait, decem horas satis esse debere, sed factum, se ipso judice, omnes theorias vincit. Non rarum est, homines optimâ valetudine frui, cum plurimum laborant, quod accidere videtur, quòd eodem tempore mercedem majorem obtinent, et dehinc ratio vivendi illis melior est.

Conatus Muscularis

Aliqui morbi e conatu musculari oriuntur. Horum hernia et aneurisma praecipui sunt. Vulnera quoque non pauca conatu vehementi producuntur. His morbis

who lift particularly heavy loads, and all who are similarly employed, are exposed to these diseases. But sometimes hernia arises from less violent effort, if it is sustained for a long time. Thus I have known a boy to be affected by hernia. He was much engaged in turning a lathe and in the course of this work the femoral and abdominal muscles were simultaneously contracted. Glassblowers also occasionally suffer from this same condition. Again it is not uncommon for a hernia to appear between the fibres of the recti muscles of the abdomen when these are weak. Other accidents occur which bring no little harm to those who are injured. Such an instance is a tear of the muscle fibres, without evidence of external injury, as often occurs in the gastrocnemii. Healing is often slow and frequently the limb remains weak throughout life. Fractures, severe external wounds, etc., are less frequent and it is not necessary to discuss them.

Posture

Workmen are often exposed to many diseases due to the posture of the body. It is already well known that scholars are liable to unusual diseases, which cannot be attributed entirely or particularly to too long-continued occupation. Indeed there are many craftsmen, who work for equally long periods in these same positions, and who do not suffer ill-effects. Such persons are coppersmiths and iron-smiths, etc., but men who work in a similar posture to scholars suffer from similar diseases. Among these diseases indigestion is specially prominent. The signs of this condition are well-known and there is no need for many words. The disturbance of the state of the mind caused by this illness is often most troublesome and should be noted above all. This condition (indigestion) affects scholars and tradesmen alike. The illness has this symptom (pain in the stomach) less often in the case of scholars ; it is more common in tradesmen. The pain is severe and persistent, and it is never possible to cure it unless the patient has given up his occupation, which has caused the condition. Weavers, makers of brooches out of bone or pearl, polishers of metal brooches, etc., are liable to the illness with a variety of the symptoms described.

Pulmonary tuberculosis is produced by this cause (posture) and occurs in these same groups of workmen.

Deformity, particularly of the spine, is another condition due to posture. This not infrequently affects girls whose employment involves a good deal of writing. The condition does not necessarily follow this work, but it results from holding the left arm under the writing tablet while the right arm is applied to the top of it. In this way the rhomboid muscles are relaxed, the humerus of the same side is pushed upwards and the left scapula projects. On one occasion I saw a boy in whom, from this cause, five or six dorsal vertebrae were not a half-thumb's distance from the scapula. Treatment of this deformity consists in correcting the way of working, bending exercises, and resting ; and carrying weights on the head according to the circumstances. Dr. Macartney writing in the *Philosophical Transactions of the Royal Society, London*, has expounded learnedly on this deformity and its remedy. All should read this contri-

pavimentorum structores, qui pondera praegravia evehunt, et omnes qui similia exercent, objiciuntur.

Sed e conatu minus vehementi, si diutius perduret interdum hernia provenit. Sic puerum novi, qui multum tornavit, in quo opere, saepissime musculi femorum abdominisque simul contrahuntur, herniâ affectum. Vitri conflatores etiam eodem morbo aliquando laborant ; et cum recti abdominis musculi, infirmi sunt, inter eorum fibras hernia non raro apparet. Alii quoque casus eveniunt non paululum incommodi laesis inferentes. Talis est musculorum fibrarum laceratio, sine vulnere externo, quae saepe gastrocnemiis accidit. Sanatio plerumque longa est, atque membrum saepe imbecillum usque ad mortem permanet. Infrequentiores sunt ossium fracturae, vulnera externa gravia etc. de quibus non necesse est, aliquid dicere.

Positio Corporis

E positione corporis, morbis multis et frequentibus homines patent. Jam dudum optimè notum est, literarum studiosos morbis peculiaribus objectos esse, qui neque omnino, neque praecipuè quidem ab occupatione nimis continuâ originem ducunt. Artifices enim multi, quibus labores sunt aeque longi, iisdemque locis, simili valetudine adversâ non afficiuntur. Tales sunt aerarii ferrariique fabri etc. sed qui laborantes, eâdem posi.ione corporis, quâ literarii, utuntur, similes morbi eos affligunt. Horum praecipuus dyspepsia videtur. Signa hujus morbi cognoscuntur, neque plurimis opus est. Illo affectorum animi infractio saepe maxime molesta, et prae aliis est notanda. Haec similiter literatos artificesque affligit ; haud raro autem dolor ventriculi ob pressuram isti organo factam, dyspepsiam comitatur. Minus saepe illis, frequentiùs his, ita morbus se habet. Dolor acutus est et praecipuè longus, nec unquam sanari potest, antequam occupationem aeger exercere cessaverit, unde exortus sit. Morbo sic variato textores, fibularum ex osse vel margaritis confectores, sutores, qui fibulas metallicas poliunt, etc. sunt obnoxii.

Ex eâdem causâ phthisis pulmonalis nascitur, et in iisdem fabris discernitur.

Alius effectus positionis corporis deformitas est, praesertim columnae vertebralis. Haec non infrequenter puellis accidit, quae multum in scribendo exercentur. Non necessariò hanc exercitationem sequitur, sed à sinistrum brachium subter tabulam tenendo oritur, dum illi dextrum imponitur. Hinc musculi rhomboidei relaxantur, humerus ejusdem lateris sursum fertur, et scapula sinistra prominet. Puerum quondam vidi, cujus quinque vel sex vertebrae dorsales non semipollicem a scapulâ sinistrâ ex hac causâ distabant. Sanatio hujus deformitatis est laborandi modum corrigere, inclinando, quiescere et pro re natâ capiti pondera sustinere. Doctor MACARTNEY hanc deformitatem et curationem in Act. Reg. Societat. Lond. scitissimè exponit, atque sermonem ejus de hâc re, omnes decet perlegere.

bution on the subject. Some consider that haemorrhoids result from posture but this, however, is not established.

Ramazzini asserts, and the opinion is widely shared at present, that standing produces varicose veins. The particular evidence in support of this consists of observations on women who are engaged in washing clothes and it is a fact that women particularly are liable to varicose veins. However, it is not quite clear that the disease affects the women because of the position used in washing. For if standing produced varicose veins in one person, the same condition ought to affect others too who have to stand. Men, however, more rarely suffer from varicose veins than do women, yet more often daily they work standing. What then is the explanation why women more often suffer from varicose veins? Pregnancy, it appears to me, is the reason as it is accompanied more or less generally by evidence of varicosity; also the custom of constricting the popliteal veins at the knees. These matters appear to have been overlooked by those who attribute the cause of varicose veins to posture. No one certainly can deny that these factors are most important. Accordingly I have not included varicose veins among the diseases of artisans.

Light and Noise

There is no need to discuss at length the subjects of light or excessive noise. Dimness of vision and hardness of hearing affect workmen whose jobs expose them unduly to bright light or great noise.

Variations of Temperature

Variations of temperature are a frequent cause of disease in artisans. In certain factories it is necessary to maintain the highest temperature. As a result the workmen sweat a great deal, and if they do not take precautions, which is very usual, a sudden congestion is caused by the cold on leaving the factory. The diseases from which these operatives are particularly liable to suffer are rheumatism, pneumonia or pleurisy, and catarrh. Pneumonia is uncommon and catarrh is less frequent in winter than in summer weather. The explanation of this appears to be that warmer clothing is worn in cold weather. Millers, glass-blowers, brewers, and similar workmen suffer in their health from this harmful influence of which I have just spoken.

But there is one disease, by far the most deadly, which is caused by changes of temperature. This is pulmonary phthisis and it seriously affects women employed in japanning.

Mechanical Irritation

Now I must deal with the most deadly cause of illnesses amongst tradesmen, namely mechanical irritation.

By mechanical irritation I mean that certain particles, which are not harmful in themselves, yet become harmful either by their quantity or because they attack the most sensitive part of the body. The habits of workmen exposed to this cause of suffering are very often intemperate. The nature of their work admittedly is an incitement to such habit, because it excites very great thirst and also they think that there are very few soft

Haemorrhoides aliqui aiunt, e positione corporis esse; non tamen hoc certum est.

E pedibus insistendo, RAMAZZINI inquit, et sententia hodie communis est, varices provenire. Testimonium praecipuum, quo hoc sustentatur a mulieribus ducitur, quae vestimenta abluunt, et verum est, foeminas varicibus admodum obnoxias esse. Non tamen aeque manifestum est, morbum a positione quâ lavantes utuntur, illas premere. Si enim in pedibus sistere, huic varices producat, illum quoque similiter in pedibus sistentem eandem aegritudinem affligere oportet. Viri autem rarius quàm mulieres varices subeunt, tamen saepius atque diutius in pedibus sistentes laborant. Quae igitur ratio est, cur foeminae saepius varicibus afficiuntur? Graviditas mihi quidem videtur, quam varices plus minusve ferè comitantur; et consuetudo poplites genualibus ligandi. Horum cogitationem illi omisisse apparent, qui causam varicum ad positionem referunt; nemo tamen negare potest, ea ad hanc rem plurimùm valere. Idcirco, varices inter morbos artificum non enumeravi.

Lux et Sonitus

De luce vel sonitu nimio, non necesse est, multum disserere. Oculorum caligo aut audiendi gravitas iis fabris contingunt, quorum opera, luce admodum fulgenti aut sonitu magno praesenti, conficiuntur.

Temperiei Mutationes

Temperiei mutationes morbos artificibus frequenter inferunt. In officinis quibusdam, necesse est, summum calorem conservare. Hinc fabris sudor magnus, et si prudentia absit, quae res saepissime occurrit, a frigore subita obstructio oritur, cùm officinas relinquunt. Morbi, quibus illi sic siti objiciuntur sunt prae omnibus rheumatismus, pneumonia vel pleuritis et catarrhus. Pneumonia infrequens est, et catarrhus hyeme quàm aestate infrequentior. Hoc accidere videtur, quia vestimenta hyeme calidiora sunt. Pistores, vitri conflatores, cerevisiae coctores et similes, valetudine ex adversâ causâ jam dictâ afficiuntur.

At morbus longe funestissimus e mutatione temperiei originem ducit. Hic phthisis pulmonalis est, et eas gravitèr affligit, quae modo Japonum aliqua ornant.

Irritatio Mechanica

Nunc de causâ artificum morborum, maximè dirâ tractandum est, nempe irritatione mechanicâ.

Ab irritatione mechanicâ, quasdam particulas per se innoxias intelligo, noxias tamen fieri, aut a quantitate earum aut quia parti praesertim excitabili corporis impinguntur. Fabrorum mores huic causae aegritudinis expositorum, sunt plerumque pravi. Opus vero ipsorum ad talem vitae rationem, incitamentum est. Sitim enim plurimum accendit, atque perpauci potus mites ad illam

Needle grinding in Redditch a century ago.

By courtesy of the Birmingham Weekly Post

drinks which alleviate this so effectively as spirits and beer.

The air of the factories is completely loaded with dust, and the workmen cannot avoid inhaling it. This fact is best observed among factory operatives employed in pointing needles and swords. The artisans themselves have long been aware of the ill-effects arising from this work. The dust consists of stone and iron and the particles are extremely fine. If you inspect the workman's face, the particles which can scarcely be discerned, shine in it, and many collect inside the nares.

The disease to which such irritating air gives rise is pulmonary phthisis, and unless some other acute illness causes the earlier death of such workmen, all succumb to it. Men continue to work for 18 or 20 years without manifesting any sign of illness, although all the time they could not avoid the accumulation of dust within the lungs. About this period, beyond which few survive, coughing commences and the usual signs of phthisis immediately follow. That the disease does not arise earlier seems to me evidence that the lungs are not particularly susceptible to irritation, for if they were easily vulnerable to attack, the duration of the workman's life also should be shorter. The following groups of workmen are affected ; needle-pointers and sword-pointers ; gun-barrel grinders ; pearl and horn button makers ; grinders of iron or brass, and many other similar occupations. It is possible to entertain some doubt as to whether the dust really enters the lung ; but although the dust is not found at post-mortem examination (which indeed ought not to be expected) many facts persuade me that this does occur. When I was investigating the facts relating to this subject, I entered, among others, a factory where gun-barrels are ground, and as I went near the grindstone I was covered with dust. Carelessly I inhaled, when suddenly I was seized with coughing which remained troublesome for 24 hours. Spasm of the glottis prevented the dust from entering

compescendam tam idoneos, quam spiritus vini et cerevisiam existimant.

Aër officinarum pulvere quam maxime oneratur, et non potest esse, quin fabri illum inspirent. Hoc in illorum officinis, qui acus vel enses acuunt, optime notum est ; et mala ex eo orta, fabri ipsi jamdiu cognoverunt. Pulvis de lapide et ferro consistit et particulae minutissimae sunt. Si faciem scruteris, vix aspectabiles, in illam micant, et intra nares multae accumulantur.

Morbus cui aër sic exasperans originem praebet est phthisis pulmonalis ; et nisi aliqua acuta aegritudo fabros tales antea perdiderit, ab eâ omnes pereunt. Octodecim vel viginti annos, sine ullo valetudinis adversae signo, perstant laborare, quamvis pulverem in pulmonem necesse est continuò accumulari. Circa hoc tempus, cui pauci supervivunt, tussis incipit, et phthiseos indicia communia extemplò sequuntur. Morbum non citius oriri, mihi testimonium videtur, pulmones non valdè irritabiles esse, si enim facilè excitari possent, vita opificum etiam brevior esse deberet. Fabri sic affecti sunt, qui acus vel enses acuunt, qui tormentorum fistulas terunt, fibulas ex margaritis vel cornibus fabricant, ferrum vel aes abradunt, multique similes. Forsitan dubium videri possit, an pulvis re verâ pulmonem intret ; sed quamvis in sectione cadaverum non invenitur (quod non oportet quidem expectare) hoc accidere multa mihi persuadent. Cum res de hoc argumento scrutarer, inter alias officinas, eam visi, quâ tormentorum fistulae teruntur, et me lapidi appropinquantem pulvis circumdedit. Incautè inspiravi, cum statim mihi tussis erat, quae per quattuor et viginti horas molesta fuit. Meum ergo pulmonem glottidis contractio spasmodica, pulverem intrare prohibuit, non fabris vero haec occurrit.

my lung, but this does not occur with workmen. Accordingly it is evident that the dust reaches the glottis, and unless the glottis is closed nothing prevents the dust from entering the bronchi, and if the bronchi, why not also the lungs? However, certain facts observed at post-mortem examination support this opinion. The lungs of workmen, who are employed in grinding iron or brass, present tuberculosis and the bronchi are similarly affected by the disease. The suffering also is such as we would expect from this cause. It is not the cough, nor the husky voice, nor even the breathlessness, which is always the first sign, but as I have found, unexpectedly, in persons who had died from other diseases, the lungs were damaged before any sign of the disease appeared. Probably asthma and throat ulceration arise from this same cause, mechanical irritation. In the greatest degree these diseases affect millers.

Chemical Irritation

The final theme of this discourse is chemical irritation, or an account of those diseases produced by harmful material handled by the workmen, or from the effluvia from the process or otherwise from emanations. This comprises those diseases which arise from the fumes of poisonous metals such as mercury, lead, etc., and those which arise from putrid effluvia, as happens with butchers, chandlers (candlemakers), hide or skin dressers, and from bad air, called in English " fire-damp ".

Of the diseases which are caused by poisonous metals, paralysis and shaking palsy caused by mercury are the most noteworthy. There are many who doubt if mercury is a harmful metal and certain individuals swallow great quantities without ill-effect. Orfila, the very distinguished French physician, who has written extensively on this subject, finally expresses this opinion : metallic mercury, it would appear, is most dangerous when in a state of extremely fine division.

Orfila writes as follows :

> " Should metallic mercury be regarded as a poison ? . . . It appears to me that metallic mercury always acts as a poison if it lodges sufficiently long in the digestive tract to achieve a high degree of division and to be absorbed. We know that moisture and fat have a most remarkable power of breaking up the particles of this metal, indeed to the point that they become black. There is then no doubt whatsoever that in the first three instances recorded [in which metallic mercury caused the characteristic signs of the disease] the mercury retained in the body has been broken down by the stomach juices and by the fat with which it has been mixed in the area of the mercury. In this state of division it was absorbed and its harmful action proceeded with more or less force." (Orfila *Toxocologie*, Tom. **1**, p. 120.)

The signs of shaking palsy are tremors of the head and limbs (usually affecting one side considerably more than the other), accompanied by abdominal pain, occasional purging, sleeplessness and also, after a time, mental derangement.

When the disease first attacks a person, the tremor is slight and occurs at longer or shorter intervals. At

Ad glottidem idcirco pulverem accidere manifestum est, et nisi rima glottidis claudatur, nihil impedit, quin bronchos ingrediatur, et si bronchos, cur non, etiam pulmones. E sectione cadaverum tamen, quaedam ad eandem sententiam adjiciuntur. Eorum pulmones, qui ferrum vel aes abradunt, tuberculas exhibent, et aeque ac bronchi morbo afficiuntur. Aegritudo etiam est, qualis ex causâ expectaremus. Non tussis, non vox rauca, non etiam dyspnoea semper primò est, sed ut inopinatè in interemptis ab aliis morbis inveni, pulmones ante noxam passi fuerunt, quam ullum signum morbi apparuisset. Ex eâdem causâ, videlicet, irritatione mechanicâ, asthma et excoriatio faucium interdum oriuntur. Hi morbi maximè apud illos qui molas curant, cernuntur.

Irritatio Chemica

Hujus sermonis, ultimum argumentum est irritatio chemica aut eorum morborum expositio, a materie noxiâ quâ fabri utuntur nascentium, aut effluviis ab opere vel aliter emissis. Haec eos comprehendit, qui a venenis metallicis, ceu hydrargyro, plumbo etc. qui ab effluviis putridis, ceu inter lanios, candelarum opifices, coriarios, atque ab aëre corrupto, Anglicè, " fire damp," proveniunt.

E morbis, qui a venenis metallicis nascuntur, paralysis tremens, ab hydrargyro, notatu est dignissima. An hydrargyrus metallicus noxius sit, multi dubitaverunt, et quidam pondera magna impunè devorarunt. ORFILA verùm Gallus celeberrimus multa de hac re disserens, tandem hanc statuit sententiam ; videlicet, hydrargyrum metallicum minutè divisum maxime nocere.

Haec sunt quae ORFILA scripsit.

> " Le mercure métallique doit-il être considéré comme un poison ? . . . Il me semble que le mercure métallique agit comme poison toutes les fois, qu'il séjourne assez de temps dans le canal digestif pour eprouver un grand degré de division et pour être absorbé. On sait que l'humidité et la graisse sont susceptibles d'atténuer prodigieusement les molécules de ce métal, an point qu'elles deviennent noires. Il n'est donc point douteux que dans les trois premières observations rapportées [in quibus hydrargyrus metallicus signa propria morbi induxisset] le mercure retenu dans le corps n'ait été divisé par les sucs de l'estomac et par la graisse avec laquelle il avait été mêlé dans la ceinture mercuriélle. Dans cet état de division il a été absorbé et son action vénéneuse s'est dévelopée avec plus ou moins d'énergie." ORFILA, *Toxocologie*, Tom. **1**, p. 120.

Signa hujus paralyseos trementis, capitis et membrorum tremores sunt, fere unum vel alterum latus praecipuè occupans, cum dolore abdominis, dejectionibus paucis et insomniis et quodam post tempore imbecillitate animi.

Cum morbus aliquem capiat, tremor levis est et intervallis longis vel brevioribus occurrit. Primo manus

first the hand or one arm shakes and the patient is unable to hold his tools. Thereafter the lower limb becomes weak and ultimately the disease spreads to all parts of the body. The bowels are usually confined, at some time there is diarrhoea and very frequently there is violent abdominal pain. By this time the workman is unable any longer to continue his job and is weak all the time. In many cases death soon results, but life, full of misery and distress, may continue for many years. Spirits or strong beer strengthen the limbs for a short time, but ultimately the disease, unhappy to relate, becomes worse.

aut brachium unum solum tremit et aeger instrumenta non potest retinere. Dehinc membrum inferius infirmum fit et postea morbus ad omnes partes corporis extenditur. Alcus fere constringitur, aliquando diarrhoea adest, et dolor abdominis saepissimè est violentus. Jam opifex non amplius laborare potest atque omnino imbecillis est. Mors haud frequentèr sequitur, sed vita tristitiâ et miseriâ plena per multos annos permanet. Spiritus vini vel cerevisia fortis pro tempore brevi artus firmant, sed postea, miserabile dictu morbus gravior recurrit.

No disease demonstrates more clearly the ineffectuality of medicine, for if drugs are not administered at the outset, the medical art can confer no beneficial effect on the patient, although neither the right moment to administer the medicines, nor the greatest mental acuteness are lacking in the physician.

Morbus nullus medicinae impotentiam magis ostendit, si enim medicamenta in initio omittantur, ars nihil commodi potest aegro afferre, quamvis nec tempus administrandi nec acies summa mentis medico desint.

I have observed the case of a man who suffered from this malady for 25 years and he had no power to hold anything. His head continually jerked from one side to the other ; his speech was interrupted by spasm of the vocal muscles, and his whole body shook without ceasing. He staggered a great deal in walking, and when he put his foot forward he shook it for a time in the air and then often drew it back again. This circumstance, happening suddenly, increased the convulsive movements, and whenever he became depressed in mind the disease got worse. His desire for food was the same as that of healthy people ; his nights were peaceful and he slept very well. His evacuations were voluntary and natural. Although shaking palsy is the more common disease which is caused by mercury, it is not the more dangerous. Sometimes workmen exhibit all the signs of disease, which many previously considered to arise from syphilis. Ulceration of the mouth and throat, caries of the nasal bones associated with profuse salivation occasionally affect workmen handling mercury. Sound teeth also fall out due to ulceration of the gums and absorption of the alveolar sockets. By this time wasting not infrequently affects the patient, " and severe wasting takes place, and unless this is dealt with, it kills the patient ". Drugs are certainly of no value in this disease, unless the patients have already given up attending at the factories.

Hominem vidi qui hunc morbum per quinque et viginti annos laboraverat atque prehendendi aliquid nulla ei erat potestas. Caput nunc hinc nunc illinc perpetuo jactabat, loquela a musculorum vocis spasmo interrupta et totum corpus continuô agitatum fuit. Ambulando multum titubavit, et cum pedem promoveret, in aëre aliquantulum vibravit, et tunc non raro iterum retraxit. Huic eventus improvisò accidens convulsiones auxit, et quandocunque mens depressa fuit, morbus ingravescebat. Cupiditas cibi, ut sanis, noctes quietae erant, et optime dormivit. Evacuationes voluntariae fuerunt et naturales.

Quamvis paralysis tremens morbus frequentior, qui ex hydrargyro nascitur, non tamen periculosior est. Aliquando omnia morbi indicia opifices occupant, quae plurimi olim a syphilide oriri existimaverunt. Ulcera oris et faucium, caries ossium nasi cum salivae effusione copiosâ, fabros qui hydrargyro utuntur, interdum consumunt. Dentes etiamsi integri decidunt, propter gingivarum ulcera et processuum alveolorum absorptionem. Jam atrophia non raro aegrum invadit, " et summa macies oritur, et nisi occurritur, tollit." Huic morbo medicamenta haud prosunt, nisi aegri prius officinas cessârit frequentare.

Again among workmen engaged in processes in which white lead is used serious diseases likewise occur.

In officinis atque operibus, ubi plumbum usurpatur, morbi admodum diri opificibus accedunt.

Not many years have passed since Sir George Baker published his discourse on painter's colic. As a cause of this disease he recognized the leaden vats, which are used to store apple juice. The malic acid dissolves the lead with the result that those who drink the liquid juice frequently suffer from severe pains in the bowels. However, although lead taken into the stomach causes disease it is not essential for the metal to make its way down into the bowel for the same effects to appear. Painters absorb fumes either through the skin or the lungs and they are liable to the same disease as those who drink cider.

Non multi anni jam elapsi sunt, cum GEORGIUS BAKER, Baronettus, sermonem de colico pictonum edidit. Pro causâ hujus morbi, vasa plumbea, in quibus succus e pomis expressus servatur, cognovit. Acidum malicum plumbum dissolvit et dehinc quicunque succum sic imbutum bibunt, dolores colicos acutos frequentèr subeunt. Quamvis autem plumbum in ventriculum receptum morbos excitat, non necesse est, ut iidem effectus manifesti sint, metallum in alvum descendere.

Vapores per cutem aut pulmones pictores absorbent, atque eidem morbo cum illis qui succum pomorum bibunt, objiciuntur.

The signs of painters' colic are most accurately described by Dr. Cullen as follows ;

" Painters' colic commences with a feeling of weight or discomfort in the abdomen, especially around the umbilicus ; followed by colicky pain, at first slight and intermittent, and increasing particularly after food ; then more severe and almost without remission, with pain in the arms and back, leading ultimately to paralysis."

In this description of the disease it is particularly worthy of note that Dr. Cullen embraced two diseases, most often occurring together, but also not infrequently occurring separately. Pain in the arms and back terminating in paralysis occurs frequently when the patient has never suffered from colic, and often colic, ending in death, tortures men whom paralysis has never affected. Orfila has extracted several such examples from the writings of Van Swieten.

The action of lead on the natural functions does not appear to be always the same. Often the patient, when the severe symptoms decrease, begins to waste away (or only the limb affected) and remains weak and free from convulsions. But Dr. Percival, writing in the *Edinburgh Medical and Surgical Journal* has recorded two instances in which the signs of the disease were similar to those caused by mercury. Orfila also described a case in which the arms were severely affected by tremors. Convulsions, however, seldom occur in this disease. Painters' colic occasionally persists for a long time and sometimes unless drugs are promptly administered, death follows after a short time.

Other metals, although harmful, do not often adversely affect workmen either because they are not extensively used, or are not easily absorbed or because they only very slightly give rise to fumes.

Now I come to the discussion of putrid animal effluvia. Ancient medical writers, and also several recently, have recognized putrid effluvia as a cause of typhoid fevers. Ramazzini, the most distinguished writer on this subject, and recently Dr. Gosse in the *Quarterly Review of Foreign Medicine*, support this opinion. However, while respecting the great name of Ramazzini, many facts convince me that the situation is otherwise ; and not only me but others whose reputation and authority among present-day day physicians are regarded in the highest degree. Of these, I may be permitted to mention Dr. Rush, formerly a physician in Philadelphia, Dr. Bancroft, writer on yellow fever, which attacks men in western India, and William Lawrence, one-time demonstrator in anatomy at St. Bartholomew's Hospital.

Dr. Bancroft has made extensive contributions to this subject and cited many examples in which there was considerable exposure to putrid effluvia, yet without causing fever or other illness.

This fact was particularly noted when decomposed corpses were removed from the cemetery of the Holy Innocents in Paris. The atmosphere was replete with putrid emanations and yet neither those living in the neighbourhood nor those engaged in the work suffered any illness. From this instance it is also possible to

Signa colicae pictonum accuratissime a Doctore CULLEN describuntur.

" Colica pictonum, praeeunte ponderis vel molestiae in abdomine praecipue circa umbilicum, sensu ; accedente dolore colico, primum levi, non continuo, et praecipue post pastum, aucto ; tandem graviore et fere perpetuo, cum dolore brachiorum et dorsi in paralysi demum abeunte."

In hâc descriptione verum notandum est, Doctorem CULLEN duos morbos amplecti, saepissimè quidem conjunctos, non raro etiam separatim occurentes. Dolor brachiorum et dorsi in paralysi demum abiens frequenter accidit, cum aeger nunquam colicam perpessus est, et saepe colica homines torquet, in mortem desinens, quos paralysis, nunquam afflixit. Aliqua hujus rei exempla ORFILA ab operibus Van SWIETEN extraxit.

Actio plumbi in functiones animalium non semper eadem videtur. Plerumque aeger, cum jam signa acuta desinunt, marcescit, (aut membrum affectum solummodo,) atque imbecillis et sine convulsione permanet, sed Dr. PERCIVAL in *The Edinburgh Medical and Surgical Journal*, duo exempla commemoravit, quibus signa morbi, iis quae ab hydrargyro oriuntur, similia fuerunt. ORFILA quoque unum exemplum dedit, in quo brachia maximè agitata sunt. Convulsiones tamen huic morbo raro accedunt. Colica pictonum aliquando longum tempus perduret, aliquando nisi medicamenta cito admoveantur, aegros brevi post tempore morti facit occumbere.

Allia metalla quamvis noxia, fabris morbos non saepe inferunt, aut quia non multum usurpantur, non facile absorberi possunt, aut vapores minimè emittuntur.

Nunc ad argumentum de effluviis putridis animalium venio. Auctores veteres medicinae, et plurimi etiam nuper effluvia putrida pro causa febrium typhoidearun agnoscunt. RAMAZZINI de hac re scriptor quidem celeberrimus, et recenter Dr. GOSSE, in *Quarterly Review of Foreign Medicine*, hanc sententiam sustinent. Mihi tamen nomen magnum RAMAZZINI verenti, rem se aliter habere, multa persuadent, nec mihi solummodo, sed aliis viris, quorum fama et auctoritas inter medicos hodie est maximè clara. Inter hos Doctorem RUSH, olim Philadelphiae medicinam exercentem, Doctorem BANCROFT de febre flavâ scriptorem, in India Occidentali homines occupanti, et GULIELMUM LAWRENCE quondam anatomiae demonstratorem in nosocomio Sancti Bartholomaei, enumerare licet.

Doctor BANCROFT de hac re copiosè disseruit, et plurima exempla dedit, ubi putredo maxima affuit, neque febris neque alius morbus consecutus est.

Praecipuè erat notabile cum cadavera putrida a sepulchreto Sant. Innocentium Parisiis removebantur. Aër putridis effluviis erat repletus, neque tamen illos qui circum habitabant neque eos qui in hoc opere versabantur, aliqua aegritudo afflixit. Ex hoc quoque

adduce additional evidence on this subject. At that time the animal substance was discovered to which the French gave the name "*adipocere*", which so closely resembled spermaceti that the love of lucre induced some persons to manufacture that substance. These manufactures were located at Conham near Bristol, and the stench of the atmosphere was exceedingly vile, yet no ill-effect was observed among the workmen. Dr. Bancroft accompanied the military expedition to Egypt where each day he breathed putrid effluvia, yet neither he himself nor any of the soldiers, who transported the dead bodies, were upset in any way.

To this evidence may be added the opinion of William Lawrence, justly a highly celebrated man. Over a period of many years he dissected bodies, and demonstrated the parts of human bodies to students. But he himself never suffered any ill-effect nor did he ever observe that the students were affected by the putrid material. Even more worthy of remark is the instance of the family which lived for many years in the place where the bodies were dissected; yet none of them ever enjoyed better or more lasting health.

Of this same fact chandlers (candlemakers) and skin or hide dressers provide proof. The stench in these workplaces is greater than in any others yet few persons enjoy better health. Butchers also, particularly those employed in slaughter-houses, never suffer any disease from this cause. Indeed in them appetite for food is increased and when they are attacked by any illness, it is accompanied by inflammation which clearly springs from excessive eating of flesh meat, in which they indulge.

From the gas, named by the English "fire-damp," asphyxia results. The condition is most frequently observed in miners but is less common, however, where the workmen use the lamps invented by Sir Humphry Davy.

Possibly there should be added cancer, which affects chimney sweepers, but the cause of this disease is still obscure.

These matters, which I have so briefly recorded, are the chief causes of the diseases which have been brought upon workmen by their occupations. But it is the greatest pity that these occupations, which are so essential, are harmful not so much in themselves as through excess and intemperance. This fact certainly is worthy of emphasis that the patients should remove these exciting causes, when they are known, for medicines can never be of real value, although generally beneficial, when these causes are continuously present. Although intemperance also frequently aggravates diseases and although the physician ought to prescribe a different way of life, the change must not be too sudden. The warning given by Celsus is very wise: "Whenever anyone wants something changed, he ought to accustom himself to it gradually."

And now I have completed this discourse. Many things, I am aware, have been omitted, and all imperfectly discussed. "But I hope I shall win forgiveness, particularly from brilliant professors, so long as it is clearly recognized that in a single city and district all occupations are not carried on," and I have not had the time to examine thoroughly all the matters which I have seen.

aliud testimonium ad eandem rem adduci potest. Eo tempore substantia animalis inventa fuit, cui Galli nomen "adipocire" imposuerunt et quae spermaceti adeo simulabat, ut amor lucri quosdam ejus fabricationen efficere induxit. Haec ad CONHAM, juxta Bristolium situm habuit, ubi foetor aëris admodum graveolentus fuit, neque illis opificibus ullum malum unquam occurrerat. Expeditionem militarem Dr. BANCROFT in Aegyptum comitatus est, atque illic effluvia putrida quotidie respiravit, neque ipsi tamen, neque militibus, qui cadavera tulerunt, aliquid fuit incommodi.

His sententia GULIELMI LAWRENCE, viri multum et merito celebris accedit. Per multos annos cadavera incidit, atque partes corporis humani tyronibus demonstravit. Sed neque ipse unquam valetudinem adversam ex hoc expertus est, neque tyrones putredine affectos esse unquam percepit. Exemplum autem notatu longe dignius est, familiae, quae per multos annos loca habitabat, ubi corpora incisa fuerunt; nullis tamen erat melior salus aut magis diuturna.

Rei ejusdem candelarum opifices et coriarii testimonium praebent. Foetor nullis officinis quam illis major adest, pauci tamen valetudine meliore gaudent. Lanii quoque praesertim qui lanienas frequentant, nunquam morbis ex hoc subeunt. Quibusdam equidem cupiditas cibi augetur, et quando valetudo adversa eos occupat, cum inflammatione est, atque a victu nimio animali, cui indulgent, manifestè oritur.

E spiritu Anglice vocato "fire-damp" asphyxia provenit, et in quibusdam fodinis, olim saepissime accidit, rarior autem est, ubi lampas, quam HUMPHRY DAVY, Baronettus, finxit, usurpatur.

His fortasse accedit cancer, qui mundatores caminorum invadit, causa verum hujus morbi adhuc obscura est.

Haec quae tam breviter memoravi praecipuae morborum causae sunt, quos occupationes opificibus induxerunt. Sed maximè dolendum est, has occupationes, quae adeo sunt necessaria, non tantum per se, quantum per luxuriam et intemperantiam noxias esse.

Forsitan expectari possit, de curatione morborum quos artes inducunt, me disserere. Hoc verò ad consilium meum non pertinet, nec multum ratio sanandi differt quâcunque causâ hujusmodi morbus nascatur. Hoc quidem notandum, has causas excitantes, cum jam notae sunt, aegri removere debent, medicamenta enim nunquam possunt prodesse, utcunque fere utilia cùm illae continuo adsunt. Quamvis intemperantia quoque saepe morbos adauget, et rationem vivendi contrariam medicum decet praescribere, mutationem non subitam esse oportet. Optimè equidem CELSUS admonet. "Cum quis mutari aliquid volet, paulatim debet assuescere."

Jam nunc hunc sermonem ad finem perduxi. Multa, bene scio, omitti, et omnia imperfectè tractari. "Veniam tamen, penes ingenuos professores praecipuè impetraturum me spero, dum satis perspectum est, non omnes artes in unâ civitate ac regione exercere" nec mihi tempus esse ut omnia illa quae vidi, perscrutarer.

FINIS

British Occupational Hygiene Society

Ordinary Scientific Meeting

An ordinary scientific meeting of the British Occupational Hygiene Society was held at the National Coal Board Mining Research Establishment, Isleworth, on January 16. The Chair was taken by the President, Dr. J. M. Rogan, and some 65 members were present.

Several communications on various aspects of occupational hygiene were presented and discussed. There were also demonstrations of flame-proof material for overalls, of a safe procedure for the removal of contaminated clothing, and of a pressurized plastic suit for wear in areas of severe contamination by toxic compounds.

Abstracts of the communications are printed below.

An Instrument for Airborne Dust Sampling in Coal-mines

R. J. HAMILTON, of the National Coal Board Mining Research Establishment, said that an instrument had been designed to meet the requirements of the National Coal Board for a dust sampler capable of unattended operation for the duration of a working shift (up to eight hours). The need for such an instrument has two causes: first, the awareness that the measurement of the average concentration of respirable dust over long periods probably gives the best estimate of the health hazard, and secondly, the large manpower requirements of a nation-wide dust sampling programme conducted with existing instruments.

The new instrument is intrinsically safe, completely self-contained, and simple to operate. Only the "respirable" dust (selected from the total airborne cloud by passage through a horizontal dust elutriator) is collected on a single microscope slide or coverslip by a combination of gravity settlement and thermal precipitation. A single sample covers the shift, giving a measure of average dustiness over the working period. Evaluation is normally by visual microscopy, but the method of collection employed gives a deposit in which the sizes are segregated, thus being particularly well suited to the use of rapid photo-electric evaluation.

Extended trials with a number of instruments have been carried out by scientists in all N.C.B. divisions, and have proved the instrument to be "pitworthy" and to give results in agreement with those from the conventional thermal precipitator.

Some Aspects of the Problem of Heat and Humidity in British Coal-mines

C. JONES, of the National Coal Board Mining Research Establishment, said that it was becoming of interest to the coal industry to have a full understanding of the climatic conditions in the deeper workings of the future, to know how these conditions would affect a miner's ability to work, and whether air-conditioning plant would be required to alleviate the situation. The objectives were, briefly, the accurate prediction of dry- and wet-bulb temperatures for new mine workings, and the understanding of how they might be controlled.

Among the many variables that affect underground climate the more important ones are strata temperature, the thermal properties of the strata, the effect of the presence of water, seasonal changes in climate at the pit-top, auto-compression of the ventilating air with depth, and the heat dissipated by machinery. Figures showing the variation of virgin strata temperature with depth and locality were obtained. The results of recent mine heat surveys illustrate the effects of the different variables.

Some well known ventilation practices which facilitate the maintenance of acceptable climatic conditions and the conflicting requirements of methane and dust control were discussed.

Of special interest is the air-conditioning of headings driven into undisturbed rock when the air is carried to the face by ducting. Recent experiments have shown that the radiation heat transfer from the warm strata to ducted refrigerated air is some five times the convection heat transfer from the returning warmer air outside the duct, and that the total moisture removed by the refrigerator is recovered by the air within a few feet of the duct end due to imperfect distribution. The radiation effect is satisfactorily reduced only by lagging the duct.

The types of air-conditioning plant used abroad were mentioned, but even the most recent installation does not properly distribute the conditioned air. The difficulties of cooling or dehumidifying the whole ventilating air stream of a mine and of conveying the conditioned air to the working places are so great that the use of small local air-conditioning units, or even of air-conditioned suits, offers an attractive alternative approach.

The Interpretation of Factory Environmental Sampling Results

E. KING, of the Department for Research in Industrial Medicine, Medical Research Council, said that the accurate interpretation of the results of any environmental investigation connected with a chronic illness requires a knowledge of the average exposure over months or years of the workmen in the factory concerned. The factors influencing this exposure, such as the existence of point sources of the toxic substances, movement of workmen, and changes in ventilation or production, make it difficult to obtain anything other than a very crude average value, based on existing conditions which often bear little resemblance to those of the past. Under these conditions the accuracy possible in sampling techniques when applied to a given place or a single workman at a given time is far ahead of our ability to relate such measurements to the expected exposure of the workmen involved. For control purposes, and in order to obtain a better knowledge of the various factors influencing exposure, a semi-quantitative continuous assessment is often preferable to very accurate average results covering a limited period.

The Control of High-current Electrical Accidents

J. P. W. HUGHES and L. A. CORNEY, of the University of Manchester and of the Central Electricity Authority, reported that in the electricity supply industry electrical accidents formed only 1% of the total but were the commonest cause of death.

Electricity has three effects : (1) of the current itself —" electrocution " ; (2) power converted into light— " arc eye " ; and (3) power converted into heat— (*a*) electrical necrosis, and (*b*) flash burns.

Electrocution was not considered, arc eye is mild, and only burning is of importance. Necrosis occurs when a person is in the path of a current ; damage is severe with gross destruction, though surgical shock is not great.

Flash burns are much commoner. Exposed skin is burnt and " metallization " may occur. In burns mortality is dependent on the area burnt, and age (Jackson, 1953). It is administratively impossible to limit ages, but burning may be controlled by stopping the clothes burning. Most severe accidents occur during temporary earthing of switch gear for maintenance, and a flame-proof coat can be worn. Ultimately all clothing materials should be flame-proof. Even an older workman has a 3 : 1 chance of survival with burning limited to the face, neck, and hands.

Other aspects of rescue and treatment are : (1) training of the teams ; (2) sending men to cover (particularly older men and the driver) ; and (3) evacuation to hospital within two hours.

After this communication the authors demonstrated the marked increase in fire resistance which had been imparted to denim overall material by treating the yarn with a proprietary compound.

Jackson, D. MacG. (1953) *Ann roy. Coll. Surg.*, **13**, 236-257.

A Procedure for Removing Heavily Contaminated P.V.C. Clothing from the Wearer

H. J. DUNSTER and R. J. SHERWOOD, Health Physics Division, A.E.R.E., demonstrated a procedure by which a man is undressed from P.V.C. protective clothing which is assumed to be very heavily contaminated by radioactive materials. The principal aim of the procedure is to avoid transferring radioactive contamination from the clothing to the wearer or to the undresser, and also to prevent contamination from spreading to clean areas. A recently developed pressurized one-piece P.V.C. suit was also available for inspection.

BOOKS RECEIVED

(Review in a later issue is not precluded by notice here of books recently received.)

Should the Patient Know the Truth ? A Response of Physicians, Nurses, Clergymen, Lawyers. Edited by Samuel Standard and Helmuth Nathan. (Pp. 160. Flexible cover 15*s*., bound 22*s*.) London : Interscience Publishers ; New York : Springer. 1955.

Artificial Respiration : With Special Emphasis on the Holger Nielsen Method. By T. O. Garland. (6*s*. 6*d*.) London : Faber & Faber. 1955.

Morale in War and Work. By T. T. Paterson. (Pp. 256 ; 18 figures, 12 tables. 18*s*.) London : Max Parrish. 1955.

Thallium Poisoning. By J. J. G. Prick, W. G. Sillevis Smitt, and L. Muller. (Pp. vi + 155 ; 21 figures. 19*s*.) London : Cleaver-Hume Press. 1955.

The Nuffield Provincial Hospitals Trust. Third Report 1951-55. (Pp. 60.) London : The Nuffield Foundation. 1955.

Ageing in Industry. By F. Le Gros Clark and Agnes C. Dunne. (Pp. x + 146 + appendix and index. 6*s*.) London : The Nuffield Foundation. 1955.

Colorimetric Chemical Pathological Estimations Using the Lovibond Comparator. (Pp. 116 ; illustrated. 18*s*. 6*d*.) Salisbury : The Tintometer Limited. 1955.

Rheumatoid Arthritis and Psoriasis Vulgaris. By Tibor Benedek. (Pp. xii + 308 ; illustrated. Price not stated.) Chicago : Dr. Tibor Benedek. 1955.

The Nuffield Foundation Tenth Report for the Year Ended 31st March, 1955. (Pp. 125.) London : The Nuffield Foundation. 1955.

Klinik und Therapie der Vergiftungen. By S. Moeschlin. (Pp. xii + 521 ; 64 figures. DM 59.-.) Stuttgart : Georg Thieme Verlag. 1956.

Exogene Faktoren in der Pathogenese der Poliomyelitis. By R. Ch. Behrend. (Pp. iv + 98. DM 14.40.) Stuttgart : Georg Thieme Verlag. 1956.

The Psychiatric Interview. By Harry Stack Sullivan. (Pp. xxiii + 246. 28*s*.) London : Tavistock Publications. 1954.

Sammlung Versorgungsund Sozialgerichtsärztlicher Gutachten aus dem Gebiete der inneren Medizin. By Heinz Meyeringh and Andreas Dietze. (Pp. xii + 480. DM 30.-.) Stuttgart : Georg Thieme Verlag. 1956.

Report by the Air Ministry on the **Health of the Royal Air Force and Women's Royal Air Force for the Year 1952.** (Roneod.)

Mental Hygiene in Public Health, 2nd ed. By Paul V. Lemkau. (Pp. xiii + 486 ; 9 figures. 60*s*.) London : McGraw-Hill. 1955.

Measurement of Responsibility. A Study of Work, Payment, and Individual Capacity. By Elliott Jaques. (Pp. xiii + 143. 15*s*.) London : Tavistock Publications. 1956.

Steel Foundry Dust Control and Ventilation. Report of Conference held at York, October 13 and 14, 1955. (Pp. 98 ; illustrated. 42*s*.) Sheffield : British Steel Castings Research Association. 1956.

The Determination of Toxic Substances in Air. A manual of I.C.I. Practice, edited by N. Strafford, C. R. N. Strouts, and W. V. Stubbings. (Pp. xxvii + 226 ; 17 figures. 35*s*.) Cambridge : W. Heffer. 1956.

Health in Industry : Sickness Absence Statistics. (Pp. 177. 35*s*.) Published on behalf of London Transport Executive by Butterworth, London. 1956.

The National Corporation for the Care of Old People. Eighth Annual Report of the Board of Governors. (Pp. 34 + accounts.) London : The Nuffield Foundation. 1956.

Guiding Principles for the Organization of Occupational Medical Services in Places of Employment. (Reprint from *Occupational Safety and Health*, Vol. V, Nos. 2-3, April–September, 1955.) (Pp. 10. 9*d*.) Geneva : International Labour Office. 1955.

Colour Measurement and Public Health. Edited by G. J. Chamberlin. (Pp. 124. 18*s*. 6*d*.) Salisbury : The Tintometer Limited. 1956.

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy held in Geneva August, 8–20, 1955. **Volume XI : Biological Effects of Radiation.** (Pp. 402 ; illustrated ; 57*s*.; $8.00.) New York : United Nations. 1956.

Industrial Accident Prevention. A Report of the Industrial Sub-Committee of the National Joint Advisory Council, Ministry of Labour and National Service. (Pp. 36. 1*s*. 6*d*.) London : H.M. Stationery Office. 1956.

Post-graduate Course in Industrial Ophthalmology

A post-graduate course in industrial ophthalmology will be held at the Birmingham and Midland Eye Hospital from Monday, July 23, to Friday, July 27, 1956.

The course is for ophthalmologists and industrial medical officers, but is open to all medical practitioners. It will include clinical demonstrations, lectures on industrial diseases and injuries, and visits to local factories and to the Burns Unit of the Birmingham Accident Hospital.

Fee : £5 5 0 for the full course.
£2 12 6 for the morning sessions only.

Syllabus can be obtained from the Secretary, Industrial Ophthalmology Course, Birmingham and Midland Eye Hospital, Church Street, Birmingham, 3.

Correction

In the paper " Coal-miners' Pneumoconiosis in Four Collieries in County Durham " (**12,** 279) we regret that the following sentence was included by mistake. It should be omitted—" . . . although recent work suggests that the attack rate of P.M.F. is greater in those men with continuing dust exposure (Cochrane, personal communication), . . . " (page 282).

The authors also point out that they wrote 39% in the second line below Table 3 on page 281 when it should be 48%.

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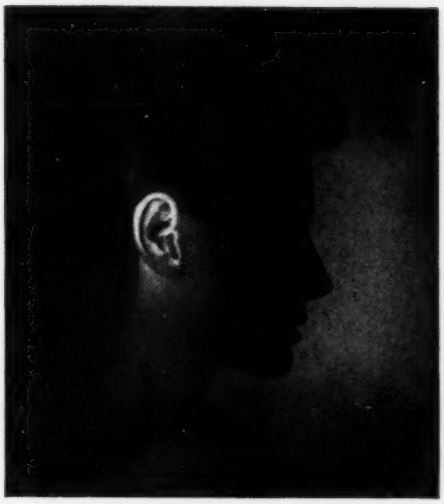

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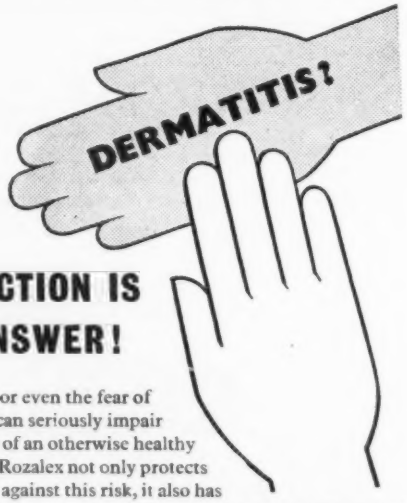

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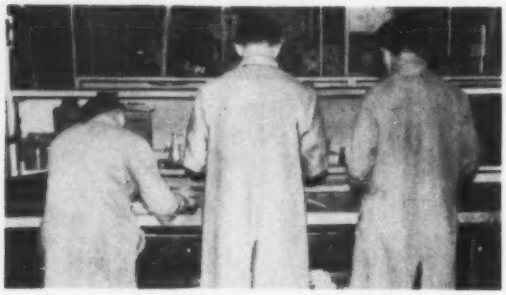

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by J. C. GILSON and P. HUGH-JONES

The principal symptom of pneumoconiosis is excessive breathlessness on exertion. This Report describes an investigation undertaken with the object of determining the precise cause of the breathlessness and relating its severity to the X-ray changes in the lung which are known to occur. The Report will be of interest not only to those concerned with the problem of pneumoconiosis but to respiratory physiologists in general.

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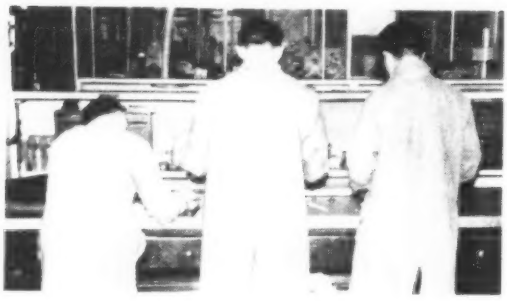

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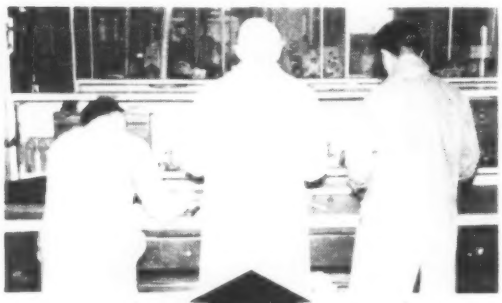

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